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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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6240
See half-page Advertisement page 91, April 19.

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PATENTS AND DESIGNS ACT, 1907.

Notice is Hereby Given that

ABSOLON WILFORD RICKS, Gentleman, residing at Rexburg, in the County of Madison, and State of Idaho, of the United States of America, seeks leave to amend the specification left in connection with the application for Letters Patent No. 109728, for "Improvements in and relating to table levelers."
Particulars of the proposed amendment were set forth in the Illustrated Official Journal (Patents), issued on the 24th April, 1918.
Any person, or persons, may give notice of Opposition to the Amendment by leaving Patents Form No. 18 at the Patent Office, 25, Southampton Buildings, London, W.C., within one calendar month from the date of the said Journal,
W. TEMPLE FRANKS, Comptroller-General.
R. B. ROYSTON & CO. (Fellows of the Chartered Institute of Patent Agents), Tower Building, Water Street, Liverpool, Agents for the Applicant. L 305

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Tenders must be enclosed in a sealed envelope endorsed "Tender for Ferro-Concrete Pontoon," and addressed to the Secretary of the Docks Committee, Docks Office, 19, Queen Square, Bristol, and must be delivered to him, accompanied by the prescribed documents and drawings, before 10 a.m. on Wednesday, 22nd May, 1918.
The Docks Committee do not bind themselves to accept the lowest or any tender.
T. A. PEACE, Engineer.
Docks Engineer's Office, Avonmouth Docks, Bristol.
30th April, 1918. L 278

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The plant is in good working condition, and can be seen by appointment.
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J. H. HALLSWORTH, Town Clerk.
Town Hall, Oldham,
April 30th, 1918. L 257

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The gentleman appointed will be required to take an active part in Day and Evening teaching.
Forms of application (which must be returned by May 15th) and further particulars may be obtained from
T. R. JOLLY, Principal and Secretary. L 244

Works Accountant Wanted

at once for progressive Controlled Engineering Works. Must be experienced in all classes of Works Accountancy, first-rate organiser with ability to get results. Employing 600 hands. State experience, naming employers in confidence, age and salary required.—Address, BOX W 538, Manchester G.P.O. L 243

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for large manufacturing concern. Must be well up in metallurgy (especially steels) and photomicrography.—Write, giving details of experience, salary required, &c., to L 173, Offices of ENGINEERING. No one already engaged on Government work or residing more than ten miles away need apply.

Chemist Required, for Large

Motor and Aeroplane manufacturing concern, must be used to the analysis of both plain and alloy steels. One with experience in other engineering materials preferred. No one on Government work considered.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting reference No. A 5134. L 249

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CHEMIST, for controlled firm of non-ferrous metal manufacturers, north-east coast. Must be a live man not afraid of work, preferably with previous works experience and knowledge of copper alloys. Excellent post-war prospects for right man. Address, stating age, full details of experience and salary required, L 100, Offices of ENGINEERING.

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for a large Aircraft Factory in Yorkshire. While some knowledge of aircraft construction is essential, discipline and organizing power are even more important. No person already engaged on Government work will be appointed.—Reply, giving age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 291.

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Department, with experience of commercial side of aeroplane manufacture, supplies, &c. No one at present employed on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 263.

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Works or Drawing Office experience, is REQUIRED for the Commercial Office of a large Engineering works in the Midlands. Applications from discharged soldiers possessing the necessary qualifications will receive special consideration.—Apply, stating salary required and giving full details of experience, to nearest EMPLOYMENT EXCHANGE, quoting this Journal and L 180. No one already on Government work will be engaged.

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Applications, stating experience and accompanied by copies of three recent testimonials, must be delivered to the BOROUGH ELECTRICAL ENGINEER, Electricity Works, 35, Fulham Palace Road, Hammersmith, W. 6, not later than Thursday, May 9th, 1918.
Candidates canvassing members of the Borough Council will be disqualified.
LESLIE GORDON, Town Clerk.
Town Hall, Hammersmith, W. 6.
April 29, 1918. L 261

Engineer, Electrical and

Mechanical. Experienced in Works Management, with knowledge of modern economical methods of production for quantity output. Motor and aeroplane parts. Must be good organiser for growing business, tactful and able to handle men. Knowledge of markets for materials and parts. Accurate costing. Excellent prospects for suitable man. London area.—Address, stating experience, qualifications, position re military service, and salary required, L 272, Offices of ENGINEERING.

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Engineers' Storekeeper

WANTED, for Controlled Establishment, must be over 30, able to control Stores Staff and must have had previous experience.—State age, particulars of your experience, salary expected, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 76. No person already employed on Government work will be engaged. L 76

Wanted, Engineer for Iron

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efficient PROGRESS or RUSH MEN for work in Scotland, previous experience in Modern Machine and Fitting Shops necessary. State age, experience, qualifications and salary required. No one already on Government work need apply.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5147. L 290

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REQUIRED at an aeroplane assembling works now in construction. Previous experience desirable though not essential. No one at present employed on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 266.

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Electrical Engineering training, experience in calibration and adjustment of precision electrical instruments, and operation of small direct and alternating currents. Salary £300 per annum.—Address replies to BOX 1394, Messrs. JAMES WILLING, 125, Strand, W.C. 2. L 307

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WANTED.

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Applicants must be competent mechanics, have had experience with internal combustion engines, D.C. generators, batteries, and electrical distribution.
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DIVISION OFFICER, Royal Engineers, 40, Forest Road West, Nottingham. L 222

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Establishment in the West Riding of Yorkshire, engaged on important high priority work, REQUIRE the SERVICES of a competent MAN, with first-class experience in General Engineering work; also experienced MAN for medium size machine tool work. No person already on Government work will be engaged.—Apply, stating full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning A 4965. K 309

A Lady Tracer is also

REQUIRED. The above positions are permanent to reliable individuals. No person already on Government work will be engaged.—Apply, stating full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning A 4966. K 309

Draughtsmen Wanted, for

Aeroplane work in Government factory. Previous experience in aeroplane design not absolutely necessary, but sound knowledge of mechanical principles essential. Good prospects for right men. No person already on Government work will be engaged.—Apply, stating experience, age and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting reference No. 4126. L 171

Draughtsmen.—Applications

requested for good experienced Mechanical DRAUGHTSMEN. Those with Crane work experience preferred.—State age, salary, experience, and when at liberty, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4428. No person already on Government work will be engaged. L 86

Draughtsman Required, with

good experience in design of Steelworks Machinery preferred, although applications from high-class men with other experience would be considered. No one already on Government work will be engaged.—State age, experience and salary required and when at liberty, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4494. K 303

Draughtsman, Mechanical

Engineering, WANTED for Controlled Factory in Scotland. Experience in Motor Vehicle or Machine Design preferable but not essential.—Apply, stating age, experience and salary expected, to nearest EMPLOYMENT EXCHANGE, mentioning this Journal and No. L 235.
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STABILITY OF AEROPLANES.

By H. A. WEBB, M.A.

§1. *Introduction.*—The conditions of stability of an aeroplane in steady horizontal flight without sideslip have been known for some years. They have been established by Bryan ("Stability in Aviation," 1911); by Bairstow, Jones and Thompson ("Technical Report of the Advisory Committee for Aeronautics," 1912–13); by Page ("The Aeroplane," second edition, 1916); and by Hunsaker (a series of articles on "The Dynamical Stability of Aeroplanes," which appeared in *Aeronautics* between September, 1916, and May, 1917). In dealing with the dynamical theory, all these authors use the method of moving axes, with which many highly-trained technical engineers are not very familiar; and it is sometimes thought that the theory of stability is of such great mathematical difficulty as to be beyond the scope of the average technical student. With this view the present writer does not agree; he thinks that the difficulty lies, not in the problem itself, but in the cumbersome mathematical machinery that has hitherto been used for its solution. The object of the present article is to give, by the use of Newton's Laws of Motion and axes fixed in space, a simple and straightforward proof of the fundamental equations of stability which, it is hoped, any technical reader will be able to follow without much trouble. No attempt is made here to discuss the practical consequences that follow from the equations of stability; these have been ably expounded in the works mentioned, and the present article is intended to be read in conjunction with one of these works, and to replace such parts of them [*i.e.*, Bryan, chapter II; Bairstow, pages 141 to 149; Fage, pages 83 to 85 and 92 to 94; and Hunsaker, §9], as have hitherto proved a mathematical stumbling-block to many readers. To facilitate this object, the standard notation is adopted here, with the single exception of the curious mathematical convention by which all these authors assume the aeroplane to be travelling with negative velocity. The *slug-foot-second system of units is used.

§2. *Steady Flight.*—Suppose the aeroplane, whose mass is m slugs, is, when undisturbed, travelling south with uniform horizontal velocity U ft. per second.

Take axes, *fixed in space*, as follows:—

O x North
O y West
and O z vertically upwards.

In steady flight, the weight of the aeroplane is balanced by the thrust of the airscrew and the air forces on the aeroplane.

We assume that in steady flight, the flight path is a principal axis of inertia of the aeroplane. This assumption is made by the authors quoted in §1 in their numerical illustrations, and probably does not introduce an appreciable error.

Let $m k_A^2$, $m k_B^2$, $m k_C^2$, in slug-foot^2 units, be the moments of inertia of the aeroplane about its three principal axes, which, in steady flight, are parallel to O x, O y, Oz.

§3. *Disturbed Flight.*—Consider *small* disturbances from the state of steady flight. We assume that the thrust of the airscrew remains constant.

Let now the velocities of the centre of gravity of the aeroplane, in feet per second, be

$$(-U+u,\ v,\ w)$$

parallel to Ox, Oy, Oz,

and let the angular displacements of the aeroplane about the axes, in radians, be

$$(\phi,\ \theta,\ \psi)$$

about O x, O y, O z;

i.e., θ = angle of *pitch*, raising the nose;
ϕ = angle of *roll*, raising the right wing:
ψ = angle of *yaw*, swinging the nose to the left.

Let the angular velocities of the aeroplane about the axes, in radians per second, be

$$(p,\ q,\ r),$$

so that

$$p = \frac{d\phi}{dt},\quad q = \frac{d\theta}{dt},\quad r = \frac{d\psi}{dt}.$$

* A slug is 32.2 lb.

We assume that u, v, w, θ, ϕ, ψ, p, q, r are all small quantities, whose squares and products will be neglected.

Applying Newton's Laws of Motion, we shall equate the force to the rate of change of momentum in the three directions O x, O y, O z; and we shall equate the torque to the rate of change of angular momentum about the three axes O x, O y, O z; obtaining six equations of motion.

§4. *Rate of Change of Momentum.*—This is:

$$m\frac{du}{dt} \text{ lb. parallel to O } x,$$

$$m\frac{dv}{dt} \text{ lb. parallel to O } y,$$

$$m\frac{dw}{dt} \text{ lb. parallel to O } z,$$

with two additional terms as follows.

Due to pitching through an angle $d\theta$, momentum $m\,U\,d\theta$ vertically upwards is created in time dt,
i.e., there is a rate of change of momentum

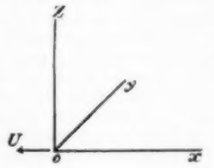
$$m\,U\frac{d\theta}{dt} = m\,U\,q \text{ lb.}$$

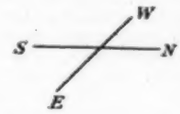
parallel to O z.

Due to yawing through an angle $d\psi$, momentum $m\,U\,d\psi$ eastwards is created in time dt.
i.e., there is a rate of change of momentum

$$-m\,U\frac{d\psi}{dt} = -m\,U\,r \text{ lb.}$$

parallel to O y.





Hence the total rate of change of momentum is:

$$\left.\begin{aligned} &m\ \frac{du}{dt} \text{ lb. parallel to O } x\\ &m\left(\frac{dv}{dt} - U\,r\right) \text{ lb. parallel to O } y\\ &m\left(\frac{dw}{dt} + U\,q\right) \text{ lb. parallel to O } z \end{aligned}\right\} \quad . \quad (1)$$

§5. *Rate of Change of Angular Momentum.*—This is:

$$\left.\begin{aligned} &m\,k_A{}^2\,.\,\frac{dp}{dt} \text{ lb. ft., about O}x\\ &m\,k_B{}^2\,.\,\frac{dq}{dt} \text{ lb. ft., about O } y\\ &m\,k_C{}^2\,.\,\frac{dr}{dt} \text{ lb. ft., about O } z \end{aligned}\right\} \quad . \quad . \quad (2)$$

There are also gyroscopic terms, due to the rotation of angular momentum, such as, for instance,

$$m\,k_C{}^2\,q\,r \text{ lb. ft., about O } x,$$

due to rotating the angular momentum

$$m\,k_C{}^2\,.\,r, \text{ about O } z$$

round the axis O y at rate q.

But all these gyroscopic terms involve products of the small quantities p, q, r, and are therefore negligible (see §3), so that the expressions in (2) are correct.

It may be remarked that some of the gyroscopic terms might have an important effect on the stability of banked or spiral flight.

§6. *Forces.*—These are due to two causes:

(i) Even if the air forces remained constant, the air forces and the thrust of the airscrew, which keep a constant attitude relative to the aeroplane would no longer quite balance the weight of the aeroplane, which, of course, still acts vertically downwards.

There are, in fact, unbalanced forces:

$$\left.\begin{aligned} &m\,g\,\theta \text{ lb. parallel to O } x\\ \text{and}\quad &-m\,g\,\phi \text{ lb. parallel to O } y \end{aligned}\right\} \quad . \quad . \quad (3)$$

(ii) The air forces have changed slightly.

The small unbalanced parts of the air forces are:

$$\left.\begin{aligned} &m\,(u\,X_u + w\,X_w + q\,X_q) \text{ lb. parallel to O } x\\ &m\,(v\,Y_v + p\,Y_p + r\,Y_r) \text{ lb. parallel to O } y\\ &m\,(u\,Z_u + w\,Z_w + q\,Z_q) \text{ lb. parallel to O } z \end{aligned}\right\} \quad (4)$$

where X_u, &c., are the so-called "resistance derivatives." The methods of finding them, by theory or experiment, for any aeroplane, are fully explained in the works quoted in §1.

§7. *Torques.*—These are due to the slight changes in the air forces, and may be written:

$$\left.\begin{aligned} &m\,(v\,L_v + p\,L_p + r\,L_r) \text{ lb. ft. about O } x\\ &m\,(u\,M_u + w\,M_w + q\,M_q) \text{ lb. ft. about O } y\\ &m\,(v\,N_v + p\,N_p + r\,N_r) \text{ lb. ft. about O } z \end{aligned}\right\} \quad . \quad (5)$$

where L_v, &c., are resistance derivatives.

§8. *Equations of Motion.*—Applying Newton's Laws of Motion, we equate (1) to the sum of (3) and (4), and equate (2) to (5).

We assume, in the usual way for small disturbances, that u, v, w, θ, ϕ, ψ, and therefore also p, q, r, are proportional to $e^{\lambda t}$, where λ is a constant to be determined.

$$\therefore\quad \frac{du}{dt} = \lambda u, \text{ etc.}$$

and

$$\theta = \frac{q}{\lambda},\ \phi = \frac{p}{\lambda},\ \psi = \frac{r}{\lambda}.$$

The six equations of motion are:

$$\left.\begin{aligned} &u(\lambda - X_u) - w\,X_w - q\left(\frac{g}{\lambda} + X_q\right) = 0\\ &-u\,Z_u + w(\lambda - Z_w) + q\,(U - Z_q) = 0\\ &-u\,M_u - w\,M_w + q(\lambda k_B{}^2 - M_q) = 0 \end{aligned}\right\} \quad . \quad (6)$$

for longitudinal disturbances, and

$$\left.\begin{aligned} &v(\lambda - Y_v) + p\left(\frac{g}{\lambda} - Y_p\right) - r\,(U + Y_r) = 0\\ &-v\,L_v + p\,(\lambda\,k_A{}^2 - L_p) - r\,L_r = 0\\ &-v\,N_v - p\,N_p + r\,(\lambda\,k_C{}^2 - N_r) = 0 \end{aligned}\right\} \quad (7)$$

for lateral disturbances.

From equations (6) u, w and q are easily eliminated and the resulting equation for λ may be written:

$$A_1\lambda^4 + B_1\lambda^3 + C_1\lambda^2 + D_1\lambda + E_1 = 0 \quad . \quad (8)$$

Similarly the elimination of v, p and r from (7) leads to an equation for λ which may be written:

$$A_2\lambda^4 + B_2\lambda^3 + C_2\lambda^2 + D_2\lambda + E_2 = 0 \quad . \quad (9)$$

Bairstow (*loc. cit.* page 160) has shown that (8) and (9) may be split into approximate factors, with sufficient accuracy for practical purposes, as follows:—

From (8),

$$(A_1\lambda^2 + B_1\lambda + C_1)[C_1{}^2\lambda^2 + (C_1\,D_1 - B_1\,E_1)\lambda + E_1\,C_1] = 0 \quad (10)$$

for longitudinal disturbances.

From (9),

$$\left.\begin{aligned} &\left(\lambda + \frac{E_2}{D_2}\right)\left(\lambda + \frac{B_2{}^2 - A_2\,C_2}{A_2\,B_2}\right)\\ &\left[\lambda^2 + \left(\frac{C_2}{B_2} - \frac{E_2}{D_2}\right)\lambda + \frac{B_2\,D_2}{B_2{}^2 - A_2\,C_2}\right] = 0 \end{aligned}\right\} \quad . \quad (11)$$

for lateral disturbances.

(10) and (11) are the fundamental equations of longitudinal and lateral stability respectively.

SCIENTIFIC UNREST.

WHEN the historian of the future applies himself to elucidating the causes of unrest in this revolutionary age he must, if he is to succeed, pay more attention to the influence of science than similar writers have done in the past. History has not developed independently of science, whether the progress has been gradual or precipitate. Social stability has been much affected by developments of engineering, and indeed, by general scientific advance. When scientific knowledge and the advantages it confers were the privilege of a small caste, human lives did not count, and the masses brooded in abject misery until somebody showed them that broken chains could serve as powerful weapons. We need not go back to the age of the Pyramids, when thousands of men could as readily be commandeered for moving huge blocks of stone as for slaying peaceful neighbours, to exemplify those conditions. Periods of relative general ease do not make history and do not engender striking advances. But an age in which man learns to fly, to send instantaneous messages across continents and oceans, to dissect the atom, to build houses as high as steeples and ships capable of accommodating the population of a provincial town, and to destroy his own strongest structures by missiles from the far distance or from the clouds—such an age is certain to make him restless and reckless, intolerant of restraint as well as of weakness.

When Lord Salisbury addressed the British Association at Oxford in 1894, he "devoted his

observations to a survey, not of our science, but of our ignorance." Sir Oliver Lodge, the president of the Birmingham meeting, nearly twenty years later, considered "rapid progress combined with fundamental scepticism as characteristic of the promising, though perturbing times in which we live." True science is always sceptical and on the alert, lest it assert more than the facts warrant, and important factors be overlooked. But science had become too dogmatic in the past century, and the students found too much pulpit orthodoxy in the professorial chair. Purely scientific discussion degenerated into petty personal controversies, and the young scientist began to doubt his masters while retaining his respect for the great leaders of scientific thought. The astounding development of electrical engineering in particular inspired the worker with confidence in himself. Here was a science which, apart from certain branches, had long appeared limited to the study and laboratory, and which now conquered the factory, the public roads and our houses. That was mainly the work, not of the front bench of technical meetings, but of the young men further behind, and the result not of lucky hits, but of hard persevering research and of painstaking systematic attention to measurements.

Other triumphant achievements taught the lesson of daring. What chemistry accomplished was for the general public a matter of perplexed astonishment rather than of intelligent appreciation. Even the great engineering feats, the construction of bridges, dams and canals, the harnessing of waterfalls and the sanitation of fever-stricken districts, impressed the masses more perhaps by what frequently counts least with the engineer, the vastness of the scheme, than with the actual problems solved. But horseless machines began to race on the roads at railway speeds, and the motor car, which had first been laughed at and then condemned as a useless, dangerous fancy, became indispensable within a few years. With the perfection of the internal-combustion engine the motor man took to the air, and the old dream of mankind was realised: man learned to fly. Terrible accidents did not thin the ranks of the enthusiasts. People no longer smile when flying across the ocean is talked about.

Other strange dreams seem to be fulfilled. If the transmutation of base metals into gold has not been accomplished yet, some strange transformations are going on; metals decay like living beings and generate a new gas; the constancy of mass has gone, and the schoolboy tells his father that the fundamental atom of the father's days turns out to be a complex little universe. We must not overlook that these discoveries are in reality far less startling and revolutionary than they appear. Yet we are taught that Newton's laws are only approximations and that parallel lines may intersect; Euclid has been buried long ago—far too late, unfortunately—the belief in scientific authorities has severely been shaken, and profound scepticism is in the ascendant. On the whole, these are healthy signs. When great men like Poincaré teach us that "principles are conventions and definitions in disguise," we are grateful for being assured that rigorous orthodoxy is unreasonable and unjustifiable in science. But the complacency with which the most cherished theories are abandoned, and the readiness with which scientific thought adapts itself to any novelty, is not altogether a healthy sign. Critics are too sensitive often to the taunt of being merely destructive and not constructive. The statement that an old theory fails does not saddle the critical investigator with the task of promptly proclaiming a new, better theory. Reformers who substitute their own inflexible doctrines for the infallibility against which they protest do not help us, and scientific criticism does not gain in strength by being wrapped up in a brand new theory. It is certainly advantageous to conduct a research and, if possible, to marshal diverse lines of research, with the object of testing facts from some particular point of view; but the investigator must not be carried away by his own argument, as if his aim were to establish that point.

Our age is too much in a hurry. Many papers presented to learned societies and new books show it painfully. The author has his notes, diagrams, tables and references on the table before him, and behind the table sits the secretary ready to take down fluent dictation, but staring in silent protest when the dictator hesitates, stumbles and corrects himself. The typed copy is, of course, revised, that is to say, gross blunders are corrected; proper revision would mean to rewrite the whole, and the author is already busy with other matters. We do not in the least wish to suggest that sound work is no longer done. Scientific activity has perhaps never been more general and more fruitful, and the fact that institutions devote themselves more to the elucidation of problems, too arduous for one worker and one lifetime, is one of the best guarantees of sound advance. All the same, the element of hurry is manifest in much of the work, written, like press matter, for the moment. To keep in the limelight, lest some other prophet arise, and to safeguard priority, the popular scientist turns out strings of papers on unfinished researches, supplementing and modifying one another, but rarely admitting errors and hasty conclusions. The bewildered public was not less well served when less was written.

We will refer to two instances of another type of scientific unrest and hurry. Ten years ago an agitation was set up for annual international tables of physical and technological constants. The object was praiseworthy. Great confusion prevails as to accepted values of constants, and new determinations not infrequently appear in little-accessible publications. But it was a mistake to decide on bringing out a big volume every year; it involved large expense, and put a very heavy burden on the shoulders of a few devoted workers; too many figures which had no right to pose as constants were, moreover, incorporated in the tables. The first volume, dealing with the year 1910, actually came out in 1912; the second volume followed two years later, and it was rather fortunate that the war interfered with the original project. Publication at longer intervals has meanwhile been resolved upon, we believe. The second example, concerning a special kind of constants, will further strengthen our argument against change in a hurry. Agreement as to atomic weights is imperative for any chemical work, whether scientific or commercial. Hence, an International Committee was appointed for examining all new determinations and for issuing annual international tables of atomic weight; the committee consists of Professors F. W. Clarke (Washington), W. Ostwald (Leipzig), T. E. Thorpe (London), G. Urbain (Paris). The eighth International Congress of Applied Chemistry, meeting at New York in 1912, deprecated frequent changes, however, and recommended that no change should be made before the next Congress, to be held in 1915, except in cases of absolute necessity. The war prevented that Congress, and also the free intercourse between the committee members. Yet Messrs. Clarke, Thorpe and Urbain proposed, in 1916, new values for the atomic weights of no fewer than ten elements. Among the more important changes were lead 207.2 (against 207.1 formerly) and radium 226.0 (against 226.4). As a result, accounts given in 1916 of researches conducted in 1914 and 1915 were in puzzling discord with the figures of the original accounts of 1915; we pointed this out in our comments on Professor Soddy's Royal Institution discourse on the "Complexity of Chemical Elements."* But these changes, at any rate, were based upon several independent researches conducted by distinguished workers in several countries.

The case of the changes proposed for carbon, 12.005 (against 12.00), and sulphur 32.06 (against 32.07), was different, as it was suggested merely on the strength of determinations made by Messrs. Th. W. Richards and C. R. Hoover, at Harvard College. Nobody questions the high value of the work done under Professor Richards in Cambridge, Mass. But so far hydrogen had been the only element for which a determination of the atomic weight to the third decimal had been considered safe (H = 1.008). Now the third decimal was settled for carbon, without fixing it for silver and sodium, the elements chiefly concerned in the new determination, and all this against the resolution of the Congress. In his report for 1916 Professor Ostwald, the fourth member of the committee, stated that the old table had to remain in force, as the committee had not passed any resolution; this seemed all the more advisable, he added, since the radioactive changes called for a radical revision of the conception of atomic weight. He did not protest, but very energetic protests came from Geneva, from Messrs. Ph. A. Guye and Enrique Moles, likewise distinguished workers in this field. In a series of articles of 1916 and 1917 they protested against the way in which changes had been adopted in general, and against the alteration of the atomic weight of carbon in particular, as it seemed to involve a numerical error. The criticised members of the committee have not replied, so far as we are aware. In the table for 1917 they made a further change in the case of columbium; the table for 1918 has not been issued yet, though the publication has generally taken place in September.* It seems to be a case of undue haste. There has been hurry also, perhaps, in laying down rules for standard tests. Nobody will oppose standardisation; what is required is mature deliberation and a certain flexibility of the rules; the wholesale application of a test can alone bring out its strong and its weak points. International conferences have sometimes acted in haste, however, just because, being convened for some definite purpose, they thought they must legislate, and not merely deliberate.

Will science continue to advance at an accelerated, even revolutionary rate? Will progress be checked, or a reaction set in? The historical parallel of a century ago suggests the general reaction. The wars of the French revolution of 1789 lasted twenty-five years. They started as wars of liberation, degenerated into wars of conquest, ended as wars of liberation, and led to a long period of profound reaction.

* See ENGINEERING, May 23, 1917, p. 500.

* Since these lines were written a letter by Sir Edward Thorpe has been published in the journal of the Chemical Society, in which he states that the International Committee have decided to intermit their annual reports owing to the interruption of experimental work on atomic weight and of correspondence. "As no change has been shown to be required in the table last published, it is suggested that it should be reprinted as it stands and regarded as current for 1918."

TEMPLETS, JIGS AND FIXTURES.—No. IV.

By JOSEPH HORNER.

FIGS. 84 to 89 (on page 477) show a massive fixture used for planing the taper on point rails in the Eastleigh Works of the London and South-Western Railway, for which, and subsequent drawings, acknowledgments are due to Mr. R. W. Urie, the locomotive engineer. It comprises a longitudinal piece A, shaped as in cross-section, Fig. 88, to receive the rail, which is seen outlined, and four short angle brackets B, B, and C, C, Figs. 84 to 87, disposed in pairs at each end of the carrying piece, one pair being cast together. Between this pair B, B, at the right-hand end, Figs. 84 and 87, the longitudinal member is pivoted. Between the other pair C, C, Figs. 84 and 86, the angle for planing the rail is set within a considerable range, varying from 1¼ in. in 4 ft. 6 in. to 1¼ in. in 8 ft. 4 in. Slot holes in the angle brackets C, C, permit the range of movements of the clamping bolt.

The method of securing the rails is shown in the enlarged detail, Fig. 88. Four sets of lugs D, seen also in the plan view, Fig. 85, receive eyebolts that pass through clamping plates E, with ends that fit the curves of the rail heads. The binder ends of the plates abut against shoulders in the lugs, so that the tightening of the bolts produces a toggle-like pressure against the rails. These also fulfil the function of locating blocks. Being equal in lengths, and abutting against shoulders, they centre the rails for which their lengths are made. Long slot holes in the lugs D permit of freedom of movement of the eyebolts. The bolts that hold the fixture to the table of the machine pass through slot holes in the feet of the angle brackets B and C. As the longitudinal member is unsupported except in these brackets it is made heavily to resist flexure under the cut. The metal is thick, and the deep engine-bed design of cross-section is adopted, (see Fig. 88). This, like many of the more massive

fixtures, is designed to take more than a single size of article in order to economise material and storage space. The same remark applies to the next example.

Figs. 90 to 92 annexed illustrate a fixture and jig for boring the holes for the piston rod, and for the pin of the connecting rod in crossheads of three different sizes. A bracket A is bolted against the vertical faceplate of the boring machine through the four holes seen in Fig. 91, which are marked off from Fig. 91, in which ordinary clamping bolts and plates *b*, with packing blocks *c*, are shown. The one fixture serves for three sizes of crossheads in which the heights vary, being the distances from the centre of the bores to the foot, measuring 6½ in., 4⅝ in., and 4½ in. respectively. These are provided for by locating the bracket A on the faceplate with two ⅝-in. dowel pins *d*, *d*, Fig. 91, which pass through the bracket into the faceplate.

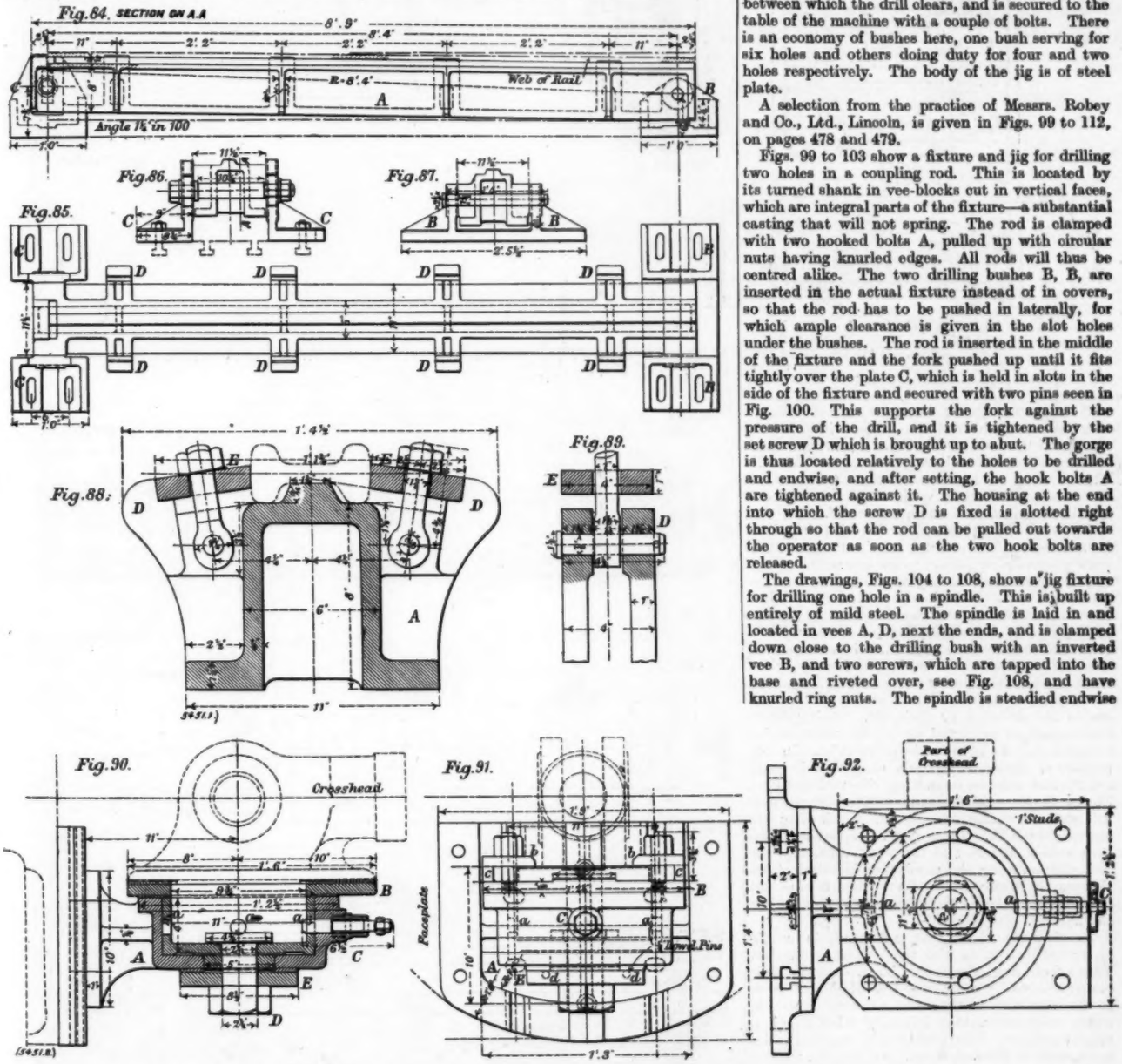
Figs. 93 to 95, page 478, show a drilling fixture and plates and permanent stud bolts. The packings, for the plates are formed solidly with the fixtures Fig. 95, thus avoiding loose packings. The drill is guided by four hard steel bushes, seen in each view, which are driven into the fixture. Thus any number of rods will be located and drilled alike without measurement or check.

Figs. 96 to 98, page 478, show a jig for drilling eight holes in superheater headers, a header being seen outlined. It is supported on two packing blocks between which the drill clears, and is secured to the table of the machine with a couple of bolts. There is an economy of bushes here, one bush serving for six holes and others doing duty for four and two holes respectively. The body of the jig is of steel plate.

A selection from the practice of Messrs. Robey and Co., Ltd., Lincoln, is given in Figs. 99 to 112, on pages 478 and 479.

Figs. 99 to 103 show a fixture and jig for drilling two holes in a coupling rod. This is located by its turned shank in vee-blocks cut in vertical faces, which are integral parts of the fixture—a substantial casting that will not spring. The rod is clamped with two hooked bolts A, pulled up with circular nuts having knurled edges. All rods will thus be centred alike. The two drilling bushes B, B, are inserted in the actual fixture instead of in covers, so that the rod has to be pushed in laterally, for which ample clearance is given in the slot holes under the bushes. The rod is inserted in the middle of the fixture and the fork pushed up until it fits tightly over the plate C, which is held in slots in the side of the fixture and secured with two pins seen in Fig. 100. This supports the fork against the pressure of the drill, and it is tightened by the set screw D which is brought up to abut. The gorge is thus located relatively to the holes to be drilled and endwise, and after setting, the hook bolts A are tightened against it. The housing at the end into which the screw D is fixed is slotted right through so that the rod can be pulled out towards the operator as soon as the two hook bolts are released.

The drawings, Figs. 104 to 108, show a jig fixture for drilling one hole in a spindle. This is built up entirely of mild steel. The spindle is laid in and located in vees A, D, next the ends, and is clamped down close to the drilling bush with an inverted vee B, and two screws, which are tapped into the base and riveted over, see Fig. 108, and have knurled ring nuts. The spindle is steadied endwise



FIGS. 84 TO 92. JIGS USED AT THE EASTLEIGH WORKS OF THE LONDON AND SOUTH-WESTERN RAILWAY; MR. R. W. URIE, M.I.MECH.E., LOCOMOTIVE ENGINEER.

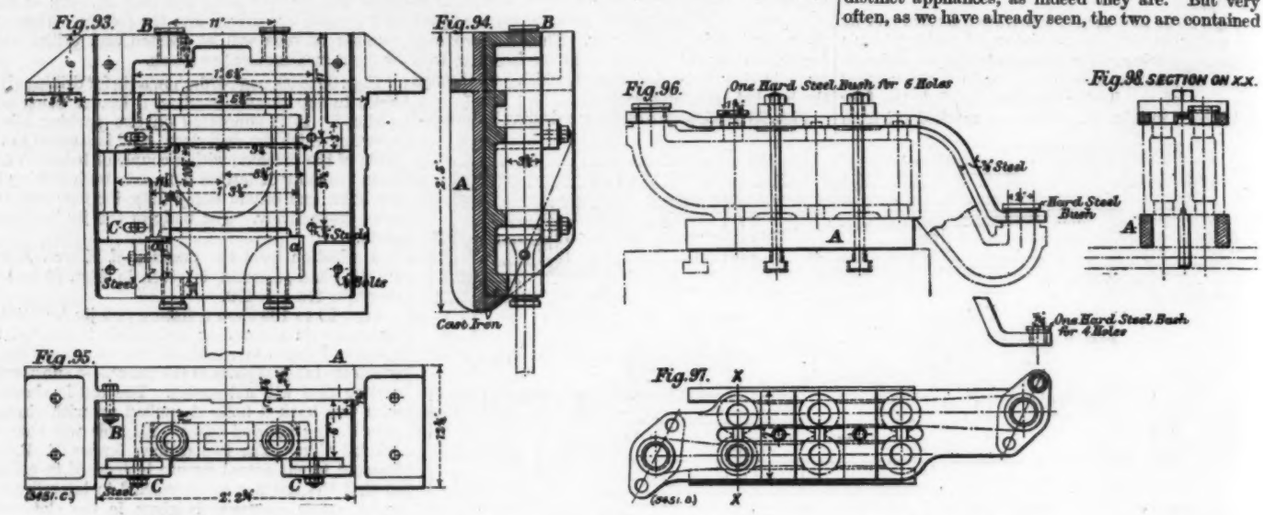
the faceplate. A deep circular recess in the bracket A receives a swivelling piece B, on which the crosshead, seen outlined, is carried, being centred and located by a tongue on B. This piece, on rotation, is locked in positions at right angles through the spring-pin C entering the tapered holes *a* in the periphery of the piece, so presenting the crosshead to the boring tools in the positions indicated in Figs. 90 and 92. The piece B is prevented from tipping under the stress of boring by the pin D going through the bottom plates of A and B and through a large washer E.

The method of holding the crosshead is shown in jig combined used for controlling the positions of the holes in the big ends of connecting rods which receive the cap bolts. The outlines of the end of the rod are dotted. The body A of the fixture is supported on and bolted to the table of the drilling machine by the flanges that extend out on each side, the rod going down into a pit. The body A embraces the actual fixture B, the portion which carries and locates the end of the rod, and which fits to A with a shallow tongue, Fig. 95, leaving clearance at the sides. A and B are of cast-iron. Blocks of steel *a*, *a*, receive the pressure of the connecting rod, which is held by four steel clamping with the abutment screw C, at the right, which pushes the other end of the spindle against the shoulder on the vee-block B. The square neck of the spindle lies in D, screwed to B in which the round portion takes its seating.

Figs. 109 to 112, page 479, show a fixture and jig for drilling two holes in coupling links with solid centres. The link is outlined at A in Fig. 109. The body of the fixture is an angle bracket B, to be moved freely on the machine table to accommodate the drill. The link is set centrally between two steel flanking pieces *a*, *a*, which are embraced by the solid body of the link. It is steadied against any tendency to

move diagonally by four pins *b*, which are tapped into the body to make a free contact with the ends of the links. Elsewhere the link is located for ready removal of worn parts. The differences in the number of identical pieces to be dealt with also determines the character of the materials used as well as of the elaboration of the jig or the fixture.

Bearing these aspects of the subject in mind the main elements of the jigs, as they are regarded in the shops, are as follows: The bushings. The location of jigs on work or of work in fixtures. The securing of pieces in fixtures. It will generally be convenient to consider the jig and the fixture as distinct appliances, as indeed they are. But very often, as we have already seen, the two are contained in one, as when a piece is held in a fixture and drilled through a jig, forming a drilling fixture, or a box jig, or a closed fixture. So, also, there are boring fixtures, and milling fixtures which combine

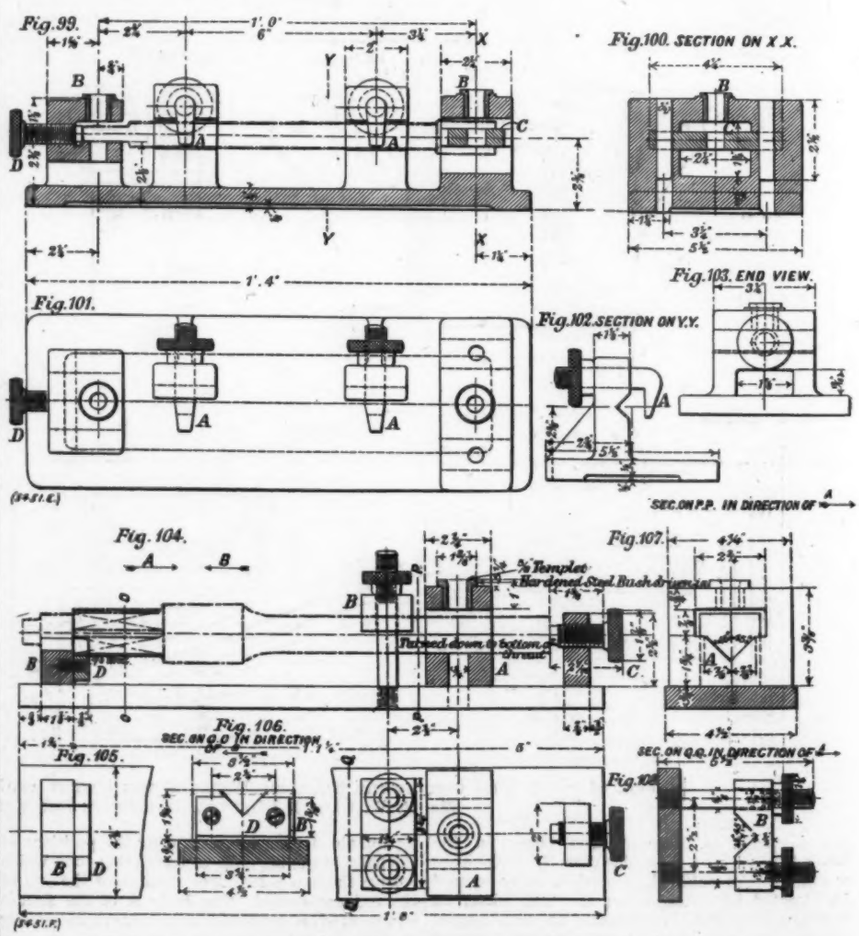


FIGS. 93 TO 98. JIGS USED AT THE EASTLEIGH WORKS OF THE LONDON AND SOUTH-WESTERN RAILWAY; MR. R. W. URIE, M.I.MECH.E., LOCOMOTIVE ENGINEER.

and supported against facings *c* and *d*. After a link has been positioned it is secured with a pivoted clamp bar C, shown also in Fig. 112, through which a clamping screw D brings pressure on the link. The pivoting of the clamp avoids taking it off its screws, which extra work would be entailed if bolt holes were drilled through the solid.

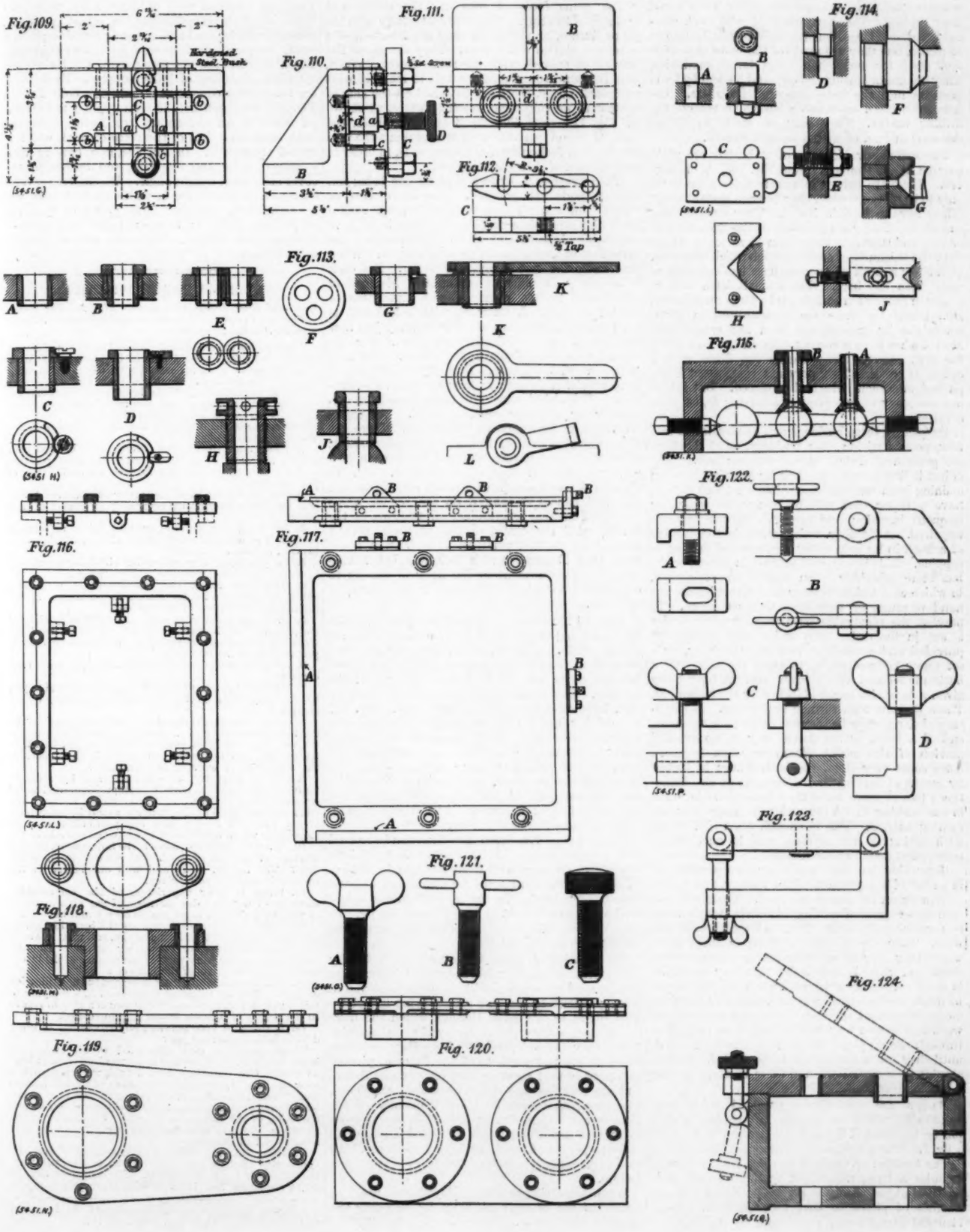
In these early articles a number of fittings have been noticed. This seems a suitable stage to make some observations relative to the essential elements of jigs and fixtures, leading up to some rather more intricate examples of these appliances to follow. Since the degree of accuracy obtained by the use of a jig or a fixture depends on that which is embodied in them it is clear that these are master elements of first-class value in the shop system of which they form an essential section. They must be subject to the same limits as the parts which are to be produced by their aid. Their pristine limits must be preserved during the whole period in which they are to be retained in service. In any number of similar pieces to be dealt with by their aid the last must be interchangeable with the first. Unless these conditions are fulfilled these aids will not accomplish the purpose which they are intended to fulfil. These facts, coupled with the very varied character of the work done, and the vast differences in the number of identical pieces that may be dealt with explain the immense amount of varied detail found in the component parts of jigs and fixtures.

The first essential is that parts made in one jig or fixture shall fit in with those made in another. This affects holes for studs, bolts, or pins, their dimensions and centres, and the relation of these to the main body of the piece or the mechanism in which they occur, thus including relations of a vital character. The relations of parts besides holes, such as those of thicknesses, lengths, widths, angles, and so forth, must be accurately determined in the fixtures. In addition to correct dimensioning it is necessary to ensure rigid and secure holding under stress of cutting, so that no part shall spring or become displaced. Neither may the setting or removal be a tedious or slow operation, but security must be combined with rapidity of operation of the parts. The larger the jig or fixture and the more complicated the piece of work dealt with, the greater becomes the task of ensuring that dimensions of holes, distances of centres, thicknesses, &c., come within limits. It is necessary to make jigs and fixtures rigid without excessive weight, since they are mostly lifted about by hand. And in the several details provision must be made for a prolonged period of service, and when that is exceeded



FIGS. 99 TO 108. FIXTURES AND JIGS AS USED BY MESSRS. ROBEY AND CO., LIMITED, GLOBE WORKS, LINCOLN.

TEMPLETS, JIGS AND FIXTURES.



the coercion of the work with that of the tool. With regard first to the bushings. Since the main portion of a fixture or jig is made in cast iron, or of soft steel plate in some smaller sizes, it is necessary to employ bushings to guide the drills, reamers and taps, because the softer body would wear rapidly. These are made of mild steel, case-hardened, if of large dimensions or for small numbers of pieces, but they are made of the more expensive tool steel for small holes and large quantities. They are ground inside and out, and pushed by hand pressure into the holes prepared for them. The holes also often have other bushes to receive the drilling bushes. They may be made to fit by screwing instead of with a smooth surface.

The non-removable permanent bushes are plain parallel in the simplest forms, Fig. 113, A, on page 479. These are driven into their holes a press fit, only to be removed when they become worn out, and others have to be substituted. They must be long enough to afford good guidance to the drill, reamer, or tap, and therefore they often have to be longer than the thickness of metal through which they pass. Ordinarily a bush of average bore has a length of more than the bore. But a small bush will be longer in proportion to bore and a large one shorter. Dimensions for these are standardised in shops where the jig practice has been well established. Most bushes have a convex edge on the end where the drill enters. Many bushes are fitted with a collar, as at B, which prevents them from being pushed into their holes and displaced. But this is not necessary when a press or a driving fit, as at A, is made.

Frequently these bushings are, as mentioned just now, pressed within other bushings, as at B, which are permanent fittings in the plate or body. The object is first to get a good fit by grinding between a lining bush and the removable one, and also to have a lining that will be removable when, by frequent insertion and removal, the fit becomes impaired. A liability which arises is the turning of a bush in its hole under the stress of drilling or tapping. This is provided against in several ways, but more especially when bushes are removable, in which case a tight driving fit is not suitable, but hand pressure, or very light hammer blows. To prevent the removable bush from turning, a slot is cut in the collar with which such bushes are provided and a pin is driven into the body, or a set screw is inserted, C, to enter the slot. Or a button is secured with a screw, and the bush being given a twist, its recess is locked by the button, D. These prevent both turning and lifting. A gland-shaped flange may be screwed down to bear on the end of a bush, or the flange may be an integral portion of the bush. When, as often happens, holes come very close, the bushes may be locked by means of flats on their collars, as at E. Sometimes two or more holes may have to be included in one bushing, F. A pin under the flange prevents turning only, G. This is enough when risk of the bush lifting is not present, and is one of the commonest and simplest fittings.

Renewable bushings are sometimes screwed in, H and J, H being turned with a tommy, and J with a spanner on its hexagonal head. These will not turn under stress of cutting, but their insertion and removal occupies some time, and the threads will wear. They are of especial value in those cases where they may be made to act as clamps to the work, and where it is desirable that they should be in close contact with the work when the drill would be liable to slip laterally, as on bevelled and convex faces. To afford support to the tool close to the work is a reason why bushes may have to project through the jig plates or the fixture wall, H and J, until they touch the surface to be drilled. This is absolutely essential when drilling is done against a bevelled surface.

Bushes are sometimes provided with long handles K, which are brought into contact with a pin or are turned down to lie against an edge of a jig, L. These are rather awkward methods.

The location of work in box jigs and in fixtures includes a large number of methods which have for their object the same precise positioning of any number of pieces so that they shall all occupy identical locations with reference to the drills or other cutting tools employed on them. These have to include the setting of rough castings and forgings which entail adjustments, and that of tooled portions which do not. Also plain and curved surfaces.

The plane faces of pins are the commonest methods of locating. These are cast solidly with the jig or fixture, or preferably they are inserted, of a hard material to resist wear. They are made flat instead of curved, with the same object. When, as is frequent, round pins are used to make contact with their edges, these are flattened on the side of contact to provide some wearing surface, as shown in Fig. 114, page 479, A, B and C. When the ends of round pins are used as abutments the pins are fitted with shoulders, as shown at D, in order to prevent risk of their displacement.

When rough-cast, or forged pieces are being set, two methods are adopted. One is to face or "spot" off a small area to make contact with a fixed abutment-piece or pin, the other is to have adjustable abutments or pins to accommodate the variations in dimensions of the rough pieces. When practicable the first is generally better. But each is necessary in different conditions. Methods of adjustment include plane surfaces and those of curved outlines. A screw E, with a lock-nut, is suitable for the first, or the screw bushings just now mentioned, and modifications of these. For the second, some form of cone or vee is used. This may be a cone F, for a bore. It may be a fixture, or have provision through a screw for endlong adjustment. Cylindrical pins are located endwise externally by a hollow cone, as at G. Vee-blocks are frequent for cylindrical bodies H. These are also adjustable, as at J, through a slot and set screw. Illustrations are hardly required to show in how many modifications these elements occur. Fig. 115 shows a double location with coned drilling bushes. The ball handle is centred on the screws which permit of making longitudinal adjustments of the handle until the cones, or one of them, take a bearing on the ball portions. The bush A is set first, then B secured with lock-nuts but having freedom of adjustment in the body of the jig to compensate for slight differences in the centres of the balls.

Fig. 116 illustrates a method of adjustment of a jig for drilling the flange of a steam chest or similar square article. It is set flush with the outside edges of the flange and is then secured with the six screws brought up to abut against the inner face of the opening. This is an alternative to outside clamping with loose clamps or with hooked bolts. Fig. 117 is a drilling jig for a square flange or the base of a casting, but shown upside down, as the casting might be stood upon it. Two edges of the piece of work are laid against the stops A, A, and the work is pushed against them, and the jig is secured by the tightening-up of the screws B against the opposite edges of the work. The screws turn in small brackets bolted to the jig.

Fig. 118, page 479, shows how holes can be located with a spigot for gland bolts or other similar objects where two or more stud holes have to be drilled. In Fig. 119 the stud holes for steam and exhaust branches are located in one templet with a spigot driven in for each hole, to be solid with the jig. In Fig. 120 the spigots are separate fittings passing through the jig into the holes.

The securing of pieces in fixtures is effected by some form of clamp with screws or bolts. The clamps used are often similar to those employed in bolting articles to machine tables, being flat plates with round or slot holes through which the bolts or the set screws pass. But while on machine tables they are independent pieces they are often made as integral portions of the fixtures, pivoted or hinged so that they are used only on one fixture and are therefore not liable to become misplaced. The clamping screws also are frequently of the thumbscrew design, Fig. 121, A and B, in preference to that of hexagonal heads or milled heads C, in order to permit of rapid clamping and release. All these, like bushes, are standardised in a good shop system.

When loose clamps are employed it is usual to avoid the use of loose packings by including the packing with the clamping plate, A, Fig. 122.

Instead of using loose clamps, hinged clamps, covers or leaves are preferred, which may often carry drilling bushes. Fig. 122, B, shows a form which pivots in a lug to lift vertically. Clamps slide round laterally as shown in a previous Fig. 109. They are clamped with ordinary bolts, with eye-bolts or with thumbscrews in great varieties. Pivots and holes are hardened and ground to prolong wear. Tapered gibs are used for lateral clamping. Eccentric bolts are not uncommon, like those used for rapid clamping of lathe poppets. Eyebolts C are among the commonest, and hook bolts D. In Fig. 123, the hook bolt is seen applied to a simple jig which is an elementary box form. Here the bush bears on a face of the piece of work which is drilled through it. In Fig. 124, is a box jig with a hinged cover and eye bolt, and bushes in the cover and one at a right angle. We shall see several examples in due course in which these designs will be elaborated. Another large group of elements effects the divisions between holes or notches—division-plate designs. These use pins or latches, with springs.

BLAST-FURNACE PRACTICE.

*Iron and Steel Institute Committee No. 2.—For Blast-Furnace Practice. Inquiry on Blast-Furnace Practice in the United Kingdom.**

THE Committee on Blast-Furnace Practice, which was formed last year, decided that in beginning their work it would serve a useful purpose to direct an inquiry into certain problems which, in their opinion, are of principal importance in their bearing on blast-furnace practice in this country, and also many questions which can only be solved by practical experience. With this object a number of questions were formulated, a list of which is given below :—

1. Please state the number of furnaces in blast at your works, the class of pig-iron made, the blast pressure and the average output per furnace for each grade of pig-iron made.

If you have more than one group of furnaces please give the above information separately in respect of each group.

2. Are your raw material supplies fairly uniform in respect of mechanical conditions, *i.e.*, size, density, &c.: (*a*) Ore, (*b*) coke, (*c*) fluxes ?

3. Do you adopt any means for obtaining regularity in respect of these conditions ? If so, what ?

4. Have you found that variations in yield and efficiency can be directly traced to variations in the mechanical conditions of the burden ?

5. Have you tried what effect the uniform grading of material has on the furnace working ? If so, have the resulting advantages outweighed the increased cost of preparation of the burden ?

6. Are your stocks exposed to the atmosphere or under cover ?

7. Have you sufficient storage capacity to enable you to effect any useful mechanical grading in making up the charges ?

8. Given that the (1) chemical composition and (2) the mechanical condition of the ores, fuel and fluxes charged do not vary widely in your current practice, to which factors do you attach most importance in their effect on the regularity of working in each case ?

9. Can it correctly be assumed that by securing uniformity in regard to chemical composition, mechanical condition, and moisture of the materials charged, the efficiency and yield of the furnaces would be increased ? If so, will you kindly give any particulars of your experience which might be of value to the committee ?

10. What in your experience is the influence on furnace working of the size of the bell in relation to the stock line ? The height, bosh, and well dimensions of the furnace in question to be given.

11. What is your experience of the comparative methods of wet and dry methods of gas cleaning, and of the application of clean gas to stoves and boilers ?

12. What in your experiences are the best thicknesses and other dimensions for lining bricks, and what methods do you recommend for preserving linings ? Do any advantages accrue from varying the quality of the bricks used in different parts of the furnace ?

13. What is your experience in regard to the utilisation of waste gases for calcining ironstone ? In replying to this question any particulars that you can give in regard to the design of roasters would be appreciated.

14. Is there, in your opinion, any advantage in using double bells for saving gas ?

These questions were circulated to all owners of blast furnaces, and replies were received from about 26 firms. The questions Nos. 1 to 9 were put with a view to eliciting opinions on the effect of the mechanical and chemical condition of the raw materials used in the blast furnace on the regularity of working and economical operation of the furnace in general. Summaries of the replies to the first nine questions are given, and these form Part I of the report.

Question No. 11, relating to gas-cleaning and the application of clean gas to stoves and boilers, will form the subject of a separate report. The questions Nos. 10 to 14 (omitting No. 11) deal with some points in the

* Report submitted at the meeting of the Iron and Steel Institute on Thursday, May 2nd, 1918.

design and construction of blast furnaces, particularly the size of bell, the quality and size of lining bricks, the use of double bells, and the utilisation of waste gases for calcining ironstone.

I. EFFECT OF THE MECHANICAL AND CHEMICAL CONDITIONS OF THE RAW MATERIALS ON THE FURNACE WORKING. (QUESTIONS 1 TO 9.)

South Wales and Monmouth.—The following remarks apply to furnaces working on hematite, and one partly on hematite and partly on basic iron, with a weekly output of 650 tons to 700 tons and 1,000 tons. The ores supplied to the works are said to be very variable in size, density, moisture and quality. At one works measures have recently been taken to ensure greater regularity in the mechanical condition of the ore; at another attempts have been made to break up large lumps of ore and stone by hand, but this method has proved very unsatisfactory.

The coke is fairly uniform and of good mechanical condition. At one place where variations in the quality of the coke had been the rule, new plant has been put down, with quenching and screening arrangements. A screening plant for limestone has also been installed to ensure cleaner stone and of greater regularity of size.

It is generally agreed in the district that very substantial advantages would result from a proper grading of material. Experiments have been made in several cases, and the results showed that the advantages would decidedly outweigh the increased cost of preparing the burden. In one case when circumstances favoured the careful selection of materials, the output of certain furnaces during a fourteen days' run is said to have been increased by 10 per cent., and the fuel consumption reduced by 10 per cent. In one case the stocks are partly under cover, and cover is said to be very desirable. For the most part the storage is quite insufficient to enable useful mechanical grading to be done in making up the burden. In general it is agreed that the efficiency and yield of the furnaces would undoubtedly be increased by securing fair uniformity in both the chemical composition, the mechanical condition, and the moisture of the materials charged.

The Midlands.—The firms in the Midlands who replied are all makers of forge and foundry iron with furnaces making from 350 tons a week up to 550 tons. Blast pressures of 5 lb., 6 lb. and 10 lb. are used, 6 lb. being the pressure in the case of most of the furnaces to which the following remarks relate.

At one place the ores are fairly uniform in respect of size and density. At others they vary greatly, being drawn from different mines, some of which send ore which is large and fairly free from smalls, while others send a large proportion of fine stone, but together they form a very regular mixture. In another instance the ore varies from riddlings to blocks only broken to wedges.

The character of the coke differs according to the source from which it is drawn. Derbyshire coke is said to be used in several instances, and it is small and sometimes contains a large proportion of dust and breeze. The limestone is clean, and is usually broken and sized at the quarries.

In the experience of one firm variations in yield and efficiency have been directly traced to variations in the mechanical conditions of the burden, and the advantages of grading would outweigh the cost. Moisture in the coke is disturbing, and small coke and fine calcined stone have a most adverse effect on the furnace, especially if the stone is insufficiently burnt and dirty. Storage capacity sufficient for grading at the works does not exist.

A Staffordshire firm has three furnaces in blast, working on forge and foundry iron. The blast pressure is 5½ lb. per square inch, and the average weekly output is 380 tons. The mechanical conditions of the raw materials are fairly uniform, and as far as these works are concerned, any advantage derived from grading material would be outweighed by the increased cost. All stocks are exposed to the atmosphere, and the storage capacity is too limited to permit of grading.

Most of the irregularity in working can be attributed to the small ores and coke or coal combined with irregularities in charging at intervals due to the human element. To get the best results, all fine material and moisture should be eliminated as far as possible from the fuel and ores, and the limestone should not exceed 5-in. cubes. One firm states that all low-grade ores, such as Northampton, should be calcined, and the resultant fine material briquetted. This, coupled with regular charging, uniform temperature, and constant pressure of blast, would reduce the likelihood of scaffolding, increase yields and prolong the life of the lining.

Another firm in the Midlands has furnaces making foundry, forge and basic iron. One furnace has a blast pressure of 7 lb. to 8 lb., and makes 700 tons to 800 tons a week, according to the class of iron. Smaller ones work at 5 lb. blast pressure, with a weekly output of 450 tons to 500 tons per furnace. The ores are very variable, with iron from 20 per cent. to 38 per cent.; silica, 3·5 per cent. to 16 per cent.; lime, 1 per cent. to 24 per cent. The size varies from large lumps to fine. The coke varies considerably in density and as to smalls and friability. The fluxes are generally uniform with some variation in winter, probably due to water. The materials are approximately graded, in so far as regularity of supplies will permit, and it is considered that this is absolutely necessary, otherwise no reliance could be placed upon the yield or quality of pig-iron produced. The stocks are exposed to the air, and there is not sufficient bunker capacity to effect useful grading. Experience shows that when supplies are running with regularity and uniformity of condition better results are obtained.

Cleveland District.—Replies were received from seven large firms in this district. The average output of the furnaces of which particulars have been given is from 900 tons to 1,200 tons per week when working on hematite. Those producing Cleveland iron yield in some cases 700 tons to 750 tons, and in others up to 1,200 tons per week. Blast pressures range from 6 lb. to 8½ lb. on the hematite furnaces, and from 6½ lb. to 8½ lb. on the Cleveland iron furnaces.

In the last twenty years the quality of both hematite and Cleveland ores used is said to have deteriorated in all cases. The hematite ores vary considerably in size at all the works, and one manager remarks that they show very great fluctuation indeed, both in respect of mechanical condition and chemical composition, varying often from 3 per cent. to 22 per cent. of silica, and 0 per cent. to 7 per cent. of lime. Stock bins or depots are installed at some furnaces, which facilitate the correct mixing of several classes of hematite ore, but in no case are they sized to uniformity. The limestone is fairly uniform in most cases, though not all the works make a practice of sizing it.

At one works some trials were made several years ago by breaking Cleveland ironstone and limestone into about 4-in. cubes. The furnace was run for three weeks on the graded material, but no saving in coke resulted, and the furnace did not drive so well with the available blast pressure of 7 lb. to 8 lb. It was not found that variations in the mechanical condition affected the yield and efficiency, except when the ores had an excessive amount of small in them. Otherwise the trials mentioned above showed that no great advantage was gained by uniform sizing, though magnetite ores which are very hard require to be broken into pieces of about 2 in. to 3-in cubes.

Another firm in the same district has also concluded, from experiments made some years ago, that no advantage is gained from grading the materials. On the other hand, four firms agree that the mechanical condition of the material charged into the furnaces has the greatest effect on the regularity of the working, but it is evident they are referring to the use of hematite ores ranging from floury smalls to very large lumps. The materials charged to Cleveland furnaces are, however, generally speaking, as constant in mechanical condition as could be desired.

All agree that the mechanical condition of the coke is a very important factor. This undoubtedly governs the driving of a blast furnace, other conditions being equal, and it is stated by one that a most helpful object of research at the present time would be to find out how to make a uniformly hard and dense coke irrespective of its ash content. The make per furnace in Clevoland would be greatly increased as the result, since the mechanical condition of the coke in the district is said to be much below the average at the present time, and one works estimated that with coke of the proper quality as to hardness and density its output would be increased by 25 per cent. At another works a furnace has actually produced immediately 30 per cent. more iron on the same ore and limestone burden by a change from poor coke to good coke. Coke of variable quality is difficult to deal with, first because of the difficulty of obtaining a reliable sample for analysing, and secondly from the fact that stocks are not kept to pick and choose from.

With regard to the relative effect of variations in chemical composition and mechanical conditions of the ores, fuel and fluxes, it is difficult to compare the influence of these, but both have an influence on the make and quality of the iron. The amount of difference could not possibly be estimated or tabulated, as blast furnaces never work to rules, and are affected by other causes (some of which are constantly varying), such as blast temperature, size of tuyeres, blast pressure, condition of lining, irregularity caused by tuyeres leaking, stoppages through breakouts, boils, &c. Generally speaking, (1) chemical composition restricts the make through producing small yield of iron and large yield of slag; (2) poor mechanical condition prevents good driving by putting a back pressure on the blast and tends to furnaces sticking and hanging. With regard to chemical composition, an abnormal amount of alumina in ores or coke will give slag troubles, which tend to small make of iron and poor quality, with high percentages of silicon and sulphur.

When furnaces have been burdened on, say, two kinds of ore of a fairly good composition the results will be pretty regular, but when a furnace has to be burdened with as many as five different kinds of ore out of six barrows to a round, as sometimes happens, the same regularity cannot be obtained.

In Cleveland practice the ironstone and limestone are calcined either separately or togethor, and the moisture in the coke need hardly be taken into account, being generally very low. The mechanical condition of the coke is of the first importance, and if uniformly hard and dense the output would be increased. The higher the iron contents the more economical would be the working of the furnace, as if the percentage of iron is constantly altering it is impossible to alter the load on the furnace as frequently as the burden changes; also, in calcining, it is equally impossible to tell exactly at a given moment the iron contents of the charge, so that an average has to be made and worked to.

Some of the larger works in the Cleveland district possess considerable storage capacity for hematite ore. The Cleveland stocks of ironstone are very small, as the close proximity to the mines ensures a regular supply. All the ironstone is passed through calcining kilns, and is thus delivered dry to the furnace. Most of the works remark that their storage capacity for hematite ore is too limited to enable them to effect useful mechanical grading in making up the charges, should that become necessary.

North-West District.—The average weekly output of 10 furnaces running on hematite is given as about 800 tons to 950 tons, the blast pressure at three different works is 5½ lb., 6 lb. and 7 lb. The ore supplies are drawn from different mines, varying in mechanical and chemical conditions from day to day, and are classified according to chemical analysis as far as possible, and there is therefore a certain amount of mechanical grading, due to the ores being spread over a large number of depots.

Otherwise than classifying the available supplies to give the best working mixture, and endeavouring to keep the same mixture on the furnace as long as possible, there has been no attempt to try the effect of uniform grading on the furnace working. The ores vary from very fine to very lumpy. With a large percentage of fine ore on the burden the yield is poor, and as a rule the furnace drives irregularly. On the other hand, with a large percentage of lumpy, dense ore, extra fuel is required, and the output is lowered. About 50 per cent. of the limestone is broken; the balance varies considerably in size. Concerning coke, the difference is marked between local coke, which is soft and friable, and good East Coast coke. The output is correspondingly lowered with the former.

In the case of companies making basic iron, the average weekly output is 950 tons to 1,000 tons, and the blast pressure is from 6½ lb. to 8 lb. The mechanical condition of the ore varies greatly. Some contain a large proportion of fines, and some vary from large lumps to wet clay material. The coke made in the company's own ovens is good mechanically and very uniform, though rather high in sulphur. The coke obtained from outside sources is very variable. The limestone is broken to uniform size, and is very good mechanically and analytically. In one instance means are adopted to ensure regularity. All ores are mixed uniformly as far as possible, and large lumps of ore are broken and the limestone broken to uniform size. The company's own coke is mixed proportionately with the foreign cokes.

Variations in yield and efficiency can be directly traced to variations in mechanical condition of the burden, and taking into consideration the quality of the iron required, the practice is to make the burden mechanically as good as possible with the materials available, and any extra cost incurred is counterbalanced by greater regularity of quality and yield.

The opinion is expressed by a maker of basic iron that by securing uniformity in regard to chemical composition, mechanical condition, and moisture in charge, there is no doubt whatever that the yield and efficiency of the furnace would be greatly increased. Both regular composition and good mechanical conditions are so very essential to good working, that it is very difficult to say which has the greater effect. Varying chemical composition of the ores causes frequent changes of burden, which should be avoided as far as possible, as this very greatly tends to disorganise the working of the furnace. Regularity is most essential for good uniform working. Bad mechanical conditions cause the furnace to work irregularly. If material is small and wet, it prevents regular flow of the reducing gases to the descending charges, with the result that the furnace hangs badly, and works in heavy slips, necessitating working the furnace down very much below its normal level. If the material is very large or dense, it is probably melted at the expense of pure carbon near the tuyeres, with a resultant loss of heat to following charges, which, of course, affects output and quality.

At another works no means are adopted for mechanical grading. The storage bunkers not being hopper bottoms, the ore going into the furnaces varies considerably. For a period it will be all fine, and at a later period it will be all lumps. It has been noted that there is a decided variation in the yield and efficiency in the working of the furnaces, owing to the mechanical condition of the burden. The stocks in both cases are exposed to the atmosphere.

Another firm has a furnace working on basic iron with an average output of 1,000 tons per week on a 35 per cent. burden. Both the size and specific gravity of the ore vary widely, but the size and density of the coke and fluxes are regular. The yield and efficiency are strongly affected if the percentage of fine ore is excessive. No mechanical grading of the materials is done, beyond using crushed limestone. The stocks are exposed to the air, and there is no storage capacity to enable any useful grading to be done at the works. Uniformity is clearly desirable, but no data exists to show how far the cost of obtaining uniformity may counterbalance or exceed the benefits to be derived therefrom, except in the case of dry blast, where the results of a three years' experience can best be described by saying that they would not warrant the repeating of the installation on another furnace.

Lincolnshire.—The replies received relate to 14 furnaces working on basic iron. Two furnaces outside the district, but using Lincolnshire ores, make about 320 tons per furnace per week. The others average from 550 tons to 600 tons, 650 tons to 700 tons, 750 tons, 800 tons, and 900 tons, and 1,100 tons per furnace per week. The blast is 5 lb. for the smaller furnaces, and from 6 lb. to 8 lb. and from 10 lb. to 12 lb. on the larger ones.

The raw materials are not at all uniform in size. The mixture of ores is self-fluxing, and they range from fines to very large pieces; as the ore is irregular the fluxes are also irregular. The ore is obtained as regular as practicable from the mines as it is raised. For one works the different grades are filled separately into wagons at the mines, and the quality is clearly marked on the wagon labels. This selected ore is marshalled at the works and shunted into position, so that by filling from different wagons a fairly uniform mixture is obtained. This is possible, owing to the fact that the filling is done direct from the wagons into barrows and not into bunkers. The stocks are exposed to the

atmosphere, but the filling into barrows is done under cover, and the filling roads are roofed over.

At two other works the large ore is broken to about 4-in. to 5-in. cubes, and the large and small are tipped into separate bins. By breaking rough stone to the extent of 10 per cent. of the total burden, the load of burden is increased by 6 per cent. In the case of coke, wagons of different brands are mixed in trainloads to empty into bins or to unload direct into barrows. The advantages of the grading described above decidedly outweigh the increased cost. Three or four days' stocks are carried in bins, and these are not under cover. The chemical composition of the burden varies widely, and assuming the mixture is maintained to produce a correct slag, which can be done even with great variation in the chemical composition; great importance is attached to the mechanical condition.

Another firm mentions the fact that the variation in the proportion of smalls both in the coke and ore has a marked effect on the yield and efficiency of the furnace. If the small material is increased to too great a proportion the furnaces work irregularly, and if the proportion of large ore increases the furnace burden has to be reduced. No experiment in uniform grading has been tried. The stocks are exposed to the atmosphere, and the ore from the calcining kilns is held in wagons and not stocked for long periods.

The chemical composition and mechanical condition affect the furnace working in a far greater degree than the moisture. When conditions happen to be favourable for a period, better results are obtained from the furnaces. In the winter, when weather conditions do not allow the mines to be worked to obtain the same regularity, the results are worse, but owing to the difficulty of obtaining particulars of the amount of irregularity this can only be stated in general terms. About 60 per cent. of the local ore is calcined at most of the works. The balance is used in a raw state.

Scotland.—The average weekly output of a group of furnaces making foundry iron is 650 tons. The ores vary considerably in size and density; the coke is uniform in size but varies in density (beehive and retort coke being used). The limestone is regular in size. Hard Swedish ores are put through a breaker, and the limestone is broken by hand; improved efficiency has been obtained by breaking the ores, but uniform grading has not been tried. The stocks are exposed to the air, and the storage capacity near the furnaces is insufficient to enable grading to be done. Given that the mechanical conditions do not vary very widely, the chemical composition of the raw material is of more importance to the regular working of the furnaces.

Trouble has been experienced through variation in the chemical composition of Spanish ore cargoes, presumably due to the ship being loaded with ore from more than one mine. In one case a difference of 4 per cent. silica was found in samples from different parts of same cargo. Some groups of furnaces making hematite pig-iron are run with a blast pressure of about 5½ lb., with a weekly production of about 350 tons.

The ore is very variable in mechanical condition. Coal is the fuel principally used, and it is poor in quality. The fluxes are fairly uniform in size. Some small ore is screened, and the fines are briquetted; it has been found that variations in mechanical conditions directly affect the yield and efficiency. All the stocks are exposed to the atmosphere.

In the case of six furnaces making basic pig-iron, the blast pressure is 3½ lb., and the average output is 280 tons per week per furnace. The ores are fairly constant, but not uniform in their mechanical condition. They contain large pieces and a great quantity of fine dust. The Rubio ore varies considerably in size.

A considerable variety of splint coals is used. They differ a good deal in size and strength, also in analyses. The furnace coke is fairly uniform, but gas cinders are often badly screened. The limestone is generally crushed, but occasionally is received in lump form. No special means are adopted for obtaining regularity, but charging the ores and other materials in rotation tends to minimise variations. The dust in the ore is detrimental, also the softness of some of the coals and the large size of some of the limestone. The stocks are exposed to the air, and not sufficient storage capacity is available for any useful grading of the raw materials. The mechanical condition of the burden is the factor which chiefly affects the furnace working, and if this were improved the yield and efficiency would be increased.

SUMMARY.

Ores.—Cleveland ironstone is uniform, and is used in lumps as mined. Lincolnshire, Northamptonshire, and Midland ores vary from lumps to small. Hematite varies from lumps to fines.

Coke.—It is difficult to give a condensed statement regarding the mechanical condition of the cokes used at the various works, but generally it may be taken that the Durham coke, owing to its greater hardness, comes to the furnaces in a more uniform condition, as compared with the softer Midland and South Yorkshire cokes. Generally it is found that with smaller makes softer cokes are used, although there are some exceptions.

Ores.—With one exception, where the ore is broken to 5-in. cubes, it is not the practice to break the ore. In two instances short time experiments have been made by breaking the ores, but no advantage was found. In the case of hard magnetite ores, these are broken to about road metal size with advantage.

Limestone.—With the exception of four works where the limestone is broken to about 4-in. cubes, limestone does not appear to be broken below 8 in. The universal opinion is that variations in yield and efficiency are directly traceable to variation in the mechanical conditions of the burden. The majority out of 23 replies have not tried uniform mechanical grading of the ores. In five cases where it has been tried advantages outweighing the increased cost have been obtained. In one case it has been tried, but no advantage found. All replies say stocks are exposed to atmosphere, but of course in case of Cleveland and other ores which are calcined the ores go into the furnace dry. Out of 21 replies, seven have sufficient storage capacity to perform mechanical grading, 12 say no, and two make a partial use of grading.

As to the relative importance of (1) the chemical composition and (2) mechanical condition of the ores, fuel, and fluxes charged in their effect on the regularity of working, six replies indicate that mechanical condition and chemical composition are equal in importance, two attribute more importance to the chemical composition, and four say that next to these conditions the most important are regularity of charging and uniformity in temperature of the blast. Special emphasis is laid upon the mechanical condition of the coke as being of primary importance in the regular blast-furnace working.

INFLUENCE ON FURNACE WORKING OF THE DIMENSIONS OF THE BELL RELATIVE TO STOCK LINE. (QUESTION NO. 10.)

The following are representative of the replies received from blast-furnace managers in most districts:—

1. A bell about 5 ft. to 6 ft. less in diameter than the furnace stock line gives better results in coke consumption and better distribution of the burden than a smaller bell. But the diameter of the bell and stock line must bear a certain proportion to the diameter of the bosh—say a 13 ft. diameter bell and 18-ft. diameter stock line for a 26-ft. diameter bosh for Cleveland.

For a 20-ft. bosh, say, a 9-ft. diameter bell and 14-ft. diameter stock line. Dimensions of furnaces as follows: For hematite iron: 10-ft. 6-in. diameter well, 20-ft. diameter bosh, height 74 ft. For Cleveland iron: 11-ft. 6-in. diameter well, 26-ft. diameter bosh, height 84 ft. A 28-ft. diameter bosh for Cleveland is thought to be correct, and for this a 13-ft. diameter bell would be put in.

2. As regards relation of bell to stock line, the area of the bell should be equal to the area of the annular space between the brickwork and the bell, when the bell is lowered. If the bell be on the small side, the large pieces will roll to the wall, and the small to the centre of the furnace, causing the blast to work up the side, to the detriment of the lining; and if on the large side, the small will go to the wall, with a consequent saving of the lining, but detrimental to the driving. The following are good lines for a furnace making Cleveland iron:—

	Ft.	In.
Height	80	0
Well	11	0
Bosh	26	0
Throat	21	0
Bell	13	9

3. The dimensions given below have been found to work very satisfactorily for hematite:—

	Ft.	In.
Height from hearth to top plates ...	75	0
,, ,, hearth to bosh	29	0
Diameter of bosh	19	0
,, well	10	0
,, bell	10	6
,, furnace at throat ...	15	0

4. The bell of the furnace must be in exact proportion to the diameter of the furnace throat, so that the material as it falls into the furnace shall be as nearly as possible evenly distributed, i.e., an annular cone must be formed by the burden having its apex exactly half-way along each of the radii. Given these conditions, the greatest benefit possible is received from the reducing gases, as they are distributed evenly through the furnace, owing to the large and small units of the burden being evenly distributed.

5. The diameter of the bell should be two-thirds of the diameter approximately of the throat of the furnace, and this gives a fairly good distribution of lumps and fine throughout the cross-sectioned area of the furnace. For a furnace 80 ft. high, with a well of 12 ft. and a bosh of 21 ft. 8 in. diameter, and a height of bosh above the well 14 ft. 6 in. and a throat diameter of 17 ft. 6 in., a bell of 11 ft. diameter gives very good results.

6. The furnaces work with greater regularity and freedom from hanging with bells of 6 ft. 9 in. to 7 ft. than with 8-ft. bells.

The particulars of three furnaces making forge and foundry iron are as follows:—

	Ft.	In.	
Height	65	0	each furnace.
Bosh	17	0	
Well	9	6	
Stock line	12	6	

7. On furnaces making forge and foundry a large number of bells of different dimensions have been tried, and the best results have been obtained from furnaces with a stock line of 15 ft. diameter and the bell 8 ft. diameter. This refers to a furnace 75 ft. high, 20 ft. bosh, 12-ft. 6-in. hearth, bosh angle 70 deg.

8. The very variable condition of the raw materials has not permitted the collection of any very conclusive data on this point. A 75-ft. furnace with well 11 ft. diameter and bosh 18 ft. by 15 ft. high has worked well with an 11-ft. bell and 15-ft. throat. A 60-ft. furnace with 9-ft. diameter well and 18-ft. diameter bosh, 15 ft. 10 in. high, worked well with a 9-ft. bell and 15-ft. throat, and at least did not do better with a 10-ft. diameter bell and 16-ft. diameter throat on hematite.

Generally speaking, the answers show that the area of the bell should be about half the area of the furnace throat at the stock line.

III. USE OF DOUBLE BELLS. (QUESTION NO. 14.)

In reply to the question as to whether there is any advantage in using double bells for saving gas, six firms answer that there is no advantage, and seven say there is great advantage. Seven have had no experience, but of these, four say there would be an undoubted saving of gas, one adding that they would not adopt the system unless they were quite sure the gas so saved would be put to a useful purpose. Two put the saving at 5 per cent. of the total gas, and one estimates the loss of gas in charging at about 6 per cent.

IV. SIZE AND QUALITY OF FIREBRICKS. (QUESTION NO. 12.)

Inquiry was made as to the best thicknesses and other dimensions of lining bricks, and what methods could be recommended for the preservation of linings. Also, whether any advantages accrue from varying the quality of the bricks used in different parts of the furnace.

The size of lining bricks used in many furnaces in the Cleveland district is 4 in. to 4½ in. thick, from 1 ft. 3 in. to 3 ft. long, and 12 in. wide. In some cases blocks or lumps 18 in. by 30 in. are used. It is largely a question of use as to what dimensions are utilised for lining-lumps. Thin bricks have the advantage of probably being better burnt; on the other hand, thick bricks can be made of greater length and are less liable to break before and after being built into the furnace. Two firms in Lincolnshire have used bricks 2½ in. to 3 in. thick for fifteen years, and are of opinion that the thin bricks are better for furnace lining than the ordinary furnace lumps, for the reason that they are better burnt. The standard sizes used are: Compass, 13½ in. by 5 in. to 6 in. by 2½ in., and 9 in. by 4 in. to 4½ in. by 2½ in.; squares, 13½ in. by 6 in. by 2½ in., and 9 in. by 4½ in. by 2½ in.

Practice varies in the use of bricks of different quality in different parts of the furnace. Five firms out of all who replied consider that there is no advantage whatever to be gained in varying the quality of the bricks, provided they are good well-burnt bricks made from a clay of average good analysis. The question is thought to be superfluous, as, according to one opinion, the best firebrick ever made cannot stand up to the temperature in the region of the tuyeres, and whatever money is spent in such refinements as dressing the hearth-lumps is thrown away, as, the moment the furnace starts to melt, it removes the surface of the bricks by fusion and replaces them by scar, which is infinitely more refractory.

Eleven other firms, however, all appear to use bricks of different quality for the upper and lower parts of the furnace. The hearth and bosh are lined with first quality bricks on account of the higher temperatures, and a lower quality, but very hard-burnt brick, is taken for the upper part, in order to resist the greater erosion, especially where the material shoots off the bell.

The advantages accruing from varying the quality of the bricks in the lining may be summed up as follows: (1) Saving in cost. (2) Best quality bricks, which are most suitable where heat is greatest, are not so well fitted for the top part of the furnace, where a lower quality brick, but better mechanically, is more suitable where a certain amount of bumping takes place by the lowering of the charges.

For preserving the lining at the top of the furnace, several firms find that a good method is to insert rolled steel protection bars at a point immediately below the gas outlet; the bars being upwards of 25 ft. long and 6 in. broad, and ½ in. thick. They are bent over a couple of feet at one end, and are inserted in the brickwork all round the furnace at the point mentioned, the bars hanging down close to the lining, and forming a shield at a point where damage is likely to be caused by the dropping in of charges, especially if the furnace is being worked low. The practice at another works is to place heavy tapered castings on the tops of and overlapping the brickwork, in order to meet the shock of materials leaving the bell. The furnaces at present blowing have been in operation about four years, and up to now there are no signs whatever of wear.

Trial has also been made with cast-iron plates built in between the courses at the part of the furnace where the material shoots off the bell and strikes the lining, but carbon diffuses into the metal and swells the cast-iron plates, so much so that it raises the level of the platform plates. Others have found no advantage from protective inner plates or other devices. They obtain specially hard-burnt firebrick blocks for the lining at the top, and special mortar.

In the opinion of one the use of water blocks above the tuyeres for protection of lining is quite unnecessary in a furnace making upwards of 1,000 tons weekly, and, in fact, they should be used very sparingly in any furnace, as instances have occurred where rows of blocks have had to be put out of commission owing to the furnaces taking water, and not being able to locate it; and, further, when a block has been found to be leaking, it is often impossible to insert a new one, owing to the lining having settled and fastened the old one in.

In some cases, for the shaft, staggered rows of open circular cast-iron cooling boxes, about 3 ft. apart, extending to 30 ft. above the bosh, are used. Four of these can be fed by a ¾-in. water-pipe, very little water being required. For the bosh, copper plate-coolers from the tuyeres to top of bosh have been employed, the thickness of lining being 22½ in. A better arrangement is to have copper plate coolers 3 ft. above the tuyeres with 27-in. lining, and water-jacketed to top of bosh with 13½-in. lining. A continuous water spray is maintained on the jacket.

A firm in the North-Western district finds that the most suitable lining brick is 4 in. by 12 in. wide at the nose by about 18 in. long. To preserve brickwork both the cascade and a modified Sahlin bosh with bronze coolers are used, which can be withdrawn when carbon deposition has taken place. At the top of the furnace

a very hard-burnt brick, higher in iron contents than those for the bosh and well, is used.

The experience of others is that the linings from the hearth up to the bosh should be thin—say from 12 in. to 15 in. thick—but with this a water casing must be applied. From the bosh upwards a lining say 2 ft. to 2 ft. 6 in., is desirable, but water might be carried (with advantage) right to the top, and in that case there is no reason why a thin lining should not work satisfactorily.

Another recommends a hearth lining not less than 3 ft. plus 6 in. of coke and tar next to the jacket. For the bosh a thickness of 9 in. inside an inverted cone of steel plate. No regular water cooling, but sprays arranged to meet emergencies. Furnace body, 24 in., in two concentric circles of blocks 12 in. long by 6 in. thick by about 24 in. wide.

V. Use of Waste Gas for Calcining Ironstone. (Question No. 13.)

In reply to the questions as to experience in the utilisation of waste gas for the purpose of calcining ironstone, 16 firms replied that they had had no experience in calcining by gas. Of the remainder, one found no gain owing to the increased cost of repairs. Another finds gas more effectual, fewer scars, more uniform result, and better control of heat, and generally satisfactory. Another says result quite successful, but takes a large amount of gas, which might be used to greater advantages in other ways. Another tried producer-gas, but cost was too high.

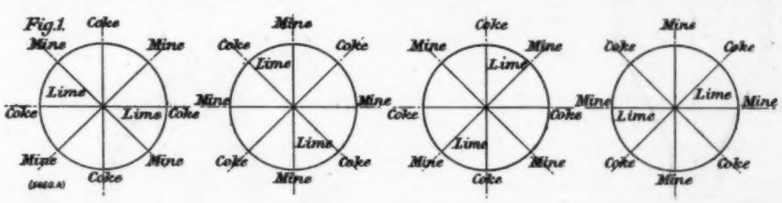
Another calcines 80 per cent. of ore by blast-furnace gas, and finds it quite successful. Kilns are of Gjers type, adapted at trifling cost to gas-firing. Gas forced in under 2 in. to 3 in. water pressure through suitable inlets. Small variable-speed fan on each kiln controls calcination. Sufficient spare gas from each furnace to calcine its own ore, if no better use can be found for it.

FUEL ECONOMY IN BLAST FURNACES.*

By Mr. T. C. Hutchinson, Skinningrove.

The Skinningrove Iron Company's blast-furnace plant consists of five furnaces, each 82 ft. high, 23 ft. diameter at throat, and 26-ft. bosh, and six blowing tuyeres. The two original furnaces have 8-ft. hearths, and Nos. 3, 4 and 5 have 10-ft. hearths.

Nos. 1 and 2 were built by the Loftus Iron Company and blown in by them on October 17, 1874. Both furnaces were damped down on May 23, 1877, when the Loftus Company went into liquidation. These two furnaces were acquired by the Skinningrove Iron Company in 1880, and were blown in on the original lining in September, 1880.



No. 1 furnace was blown continuously by the Skinningrove Iron Company from September, 1880, until 31st December, 1900, on the original lining.

No. 2 was blown in in October, 1874, and continued blowing in May, 1877, a period of 2 years and 7 months, and then again from September, 1880, until April 14, 1903, a further period of 22 years and 7 months on the original lining, a total life of one lining of 25 years and 2 months.

Nos. 3, 4 and 5 were built by the Skinningrove Iron Company with 10-ft. hearths.

No. 4 was lighted up on October 6, 1895, and is still blowing on the original lining, after a period of 22 years and 3 months.

No. 3 was lighted up on January 22, 1896, and is still blowing on the original lining, a period of 22 years.

No. 5 was lighted up on November 9, 1901, and was blown out on July 10, 1915, and is now being relined.

The furnaces blowing at this date are Nos. 1, 2, 3 and 4.

The following is the life of each furnace lining, and make of iron on original lining :—

No. 1 Furnace.

		Make in Tons.
October, 1874, to May, 1877	2 years 7 months	49,162
September, 1880, to December, 1900	20 „ 3 „	562,815
Life of lining	22 „ 10 „	
Make of iron		611,977

No. 2 Furnace.

		Make in Tons.
October, 1874, to May, 1877	2 years 7 months	50,524
September, 1880, to April, 1903	22 „ 7 „	625,362
Life of lining	25 „ 2	
Make of iron		675,886

No. 3 Furnace.

January, 1896, to January, 1918, still blowing on original lining.
Make to January, 1918, 769,900 tons.

No. 4 Furnace.

October, 1895, to January, 1918, still blowing on original lining.
Make to January, 1918, 747,674 tons.

No. 5 Furnace.

November, 1901, to July, 1915 :—
Life of lining ... ... 13 years 7 months.
Make of iron ... ... 518,257 tons

At the May meeting of the Iron and Steel Institute in 1908, I had the pleasure to present a paper on the "Mechanical Cleaning of Ironstone," and the fuel economy resulting therefrom. This paper is printed in No. III, 1908, pages 38 to 58, of the Journal of the Iron and Steel Institute. [Engineering, October 2, 1908.]

In the present paper I propose later to consider the conditions in the blast furnaces that secure such long life of furnace lining, and the fuel economy resulting therefrom ; but at the moment I will confine my remarks to the importance of effectually cleaning the ironstone at the belt, for this question of cleaning is altogether apart from that which relates to the life of furnace linings, and by either means fuel economy can be effected independent of the other.

Ten years have elapsed since 1908, when I presented my paper on mechanical cleaning of ironstone. The experience of these ten years has confirmed the figures I reported in 1908. From that date, careful attention has been given to secure the rejection at the belt of all impurities that could be mechanically treated. A check sorting bench was established near the furnaces quite apart from the cleaning belt at the heapstead. Each week two trucks of ironstone have been taken from the trains, after leaving the cleaning belt, and these trucks have been resorted by hand, putting impurities aside that had passed the belt. The clean stone from the sorting bench was then analysed, and the percentage of metallic iron in the clean stone ascertained and the consumption of ironstone per ton of pig-iron produced in the blast furnaces, compared with the report from the cleaning belt. These comparisons were made each month.

The metallic iron in the pig-iron as received from the blast furnaces was taken at 92 per cent., this being based on average analyses entered in the laboratory report.

Samples of No. 3. Foundry and Forge Pig-Iron. Average Analysis.

	Per Cent.
Graphitic carbon	2·950
Combined carbon	0·473
Silicon	2·320
Sulphur	0·049
Phosphorus	1·570
Manganese	0·550
Arsenic	0·027
Chromium	0·063
Metallic iron	91·998

The comparison instituted was as below :—

If 20 cwt. of pig-iron contained 92 per cent. metallic iron, ironstone containing 27 per cent. metallic iron should require 68·14 cwt. of ironstone to produce 20 cwt. of pig-iron.

Thus : 92 per cent. × 20 cwt. = 1,840 ÷ 27 per cent. metallic iron in ironstone = 68·14 cwt. of ironstone, and the converse—92 per cent. × 20 = 1,840 ÷ 68·14 = 27 per cent. of metallic iron in ironstone.

The actual consumption of ironstone in the furnace for the last ten years has been :—

Year ended Dec. 31.	Ironstone, Cwts. per Ton of Pig Iron.	Percentage of Metallic Iron in Ironstone.
1908	68·329	26·92
1909	70·249	26·19
1910	69·71	26·39
1911	69·78	26·36
1912	70·08	26·25
1913	69·32	26·54
1914	70·84	25·97
1915	70·45	26·11
1916	70·09	26·25
1917	70·31	26·17

For more than twenty years we have analysed every cast of pig-iron produced at the blast furnaces. The low sulphur content has proved that the sulphur band brought with the ironstone from the mines can be mechanically removed at the cleaning belt.

The average analyses for silicon and sulphur from 1895 to 1906 were as follow :—

Year.	No. 3 Iron. Silicon.	No. 3 Iron. Sulphur.	Foundry No. 4. Silicon.	Foundry No. 4. Sulphur.
1895	3.09	0.019	2.45	0.040
1896	2.35	0.025	..	..
1897	3.06	0.023	2.58	0.034
1898	2.74	0.017	2.69	0.028
1899	3.21	0.030	2.70	0.050
1900	3.44	0.034	2.58	0.032
1901	3.07	0.039	2.71	0.060
1902	3.06	0.035	2.63	0.066
1903	2.35	0.045	2.27	0.054
1904	2.52	0.051	2.47	0.053
1905	2.71	0.037	2.35	0.048
1906	2.02	0.040	2.43	0.049
	12)33.62	12)0.395	11)27.86	11)0.562
	2.80	0.033	2.53	0.051

In 1908, the date of my paper, we had no steel works. Nearly our entire make of pig-iron was sold to Scotland.

In 1911 we used part of the make as molten iron for manufacture of steel, and then realised the importance of low sulphur iron for that purpose.

At this date, January 15, 1918, I have before me the analyses of molten iron sent to the steel melting shop that day, which are as below. Out of 13 consecutive casts from the blast furnaces that day, 13 ladles of molten iron of about 30 tons each, or a total weight of metal of 390 tons, analysed as follows :—

Hot Metal Charged. Silicon.	Hot Metal Charged. Sulphur.	Mixer Metal. Silicon.	Mixer Metal. Sulphur.	Steel Made. C.	S.	P.	Mn.
3.29	0.024	0.56	0.034	0.05	0.050	0.070	—
3.10	0.030	—	—	0.44	0.050	0.046	0.69
2.30	0.044	—	—	0.42	0.045	0.037	0.74
3.39	0.025	0.87	—	0.20	0.053	0.045	0.69
3.15	0.024	—	—	0.20	0.045	0.040	0.77
3.01	0.028	—	—	—	—	—	—
2.49	0.038	0.56	—	—	—	—	—
2.87	0.036	—	—	—	—	—	—
2.96	0.050	—	—	—	—	—	—
2.72	0.023	—	—	—	—	—	—
2.77	0.036	0.47	—	—	—	—	—
2.91	0.033	0.47	—	—	—	—	—
3.01	0.041	0.42	0.035	—	—	—	—

Such low sulphur pig-iron could not have been produced if the sulphur band in the ironstone had not been mechanically removed at the cleaning belt. Fuel economy results partly from rejection of impurities before the ironstone is charged into the furnace and partly by equal distribution and admixture of the mine, coke and limestone in the furnace itself. The working of Nos. 1 and 2 furnaces in 1881 (the first full year of the Skinningrove Iron Company's operations) was not satisfactory to the management. The respective makes were : 1881, No. 1, 22,799 tons ; 1881, No. 2, 23,472 tons ; as compared with 24,985 tons, the average make for that year of all Cleveland furnaces. The iron produced was mainly forge.

Neither the works chemist (a university graduate) nor the furnace manager could suggest a remedy. It was imperative that one should be found, and for that purpose a model of the furnace was prepared and made exactly to scale (1 to 48). The charging bell was made to the same scale (13 ft.). A slide was fixed at the bottom of the model so that charges could be withdrawn during the time the model was being filled. This model was cut vertically into two equal portions and each half sheeted with glass so as to give two closed compartments when opened for examination.

The material to be charged into the model was broken to the same scale as the model. The iron stone was broken into cubes ½ in. and below of varying sizes down to dead small so as to represent the proportion of large and small calcined ironstone as charged into the furnace.

The limestone was broken into cubes of $\frac{1}{16}$ in. so as to represent the raw limestone charged into the furnace, mountain limestone being used which had to be broken by hand on arriving at the furnace, and therefore no small limestone was charged into the furnaces.

The coke to the same proportion, $\frac{1}{16}$ in. down to dead small. The experiments with this model commenced in February, 1882, and extended over several weeks. The model was charged with small buckets $\frac{1}{16}$ the capacity of the furnace mine and coke barrows. These were tipped in the hopper of the model in the same manner as the mine and coke barrows were tipped into the blast furnaces (Fig. 1).

Eighty rounds were thus filled into the model and then a portion drawn from the bottom to get a clear section of the material as it descended in the furnace. Refilling was proceeded with until the model was filled, and it was then opened and there was found in the centre of the section a column equal in the blast furnaces to 7 ft. to 8 ft., composed of coke, limestone and large mine. Similar conditions existed at the walls of the model. The ironstone, limestone and coke could be easily distinguished by the colour—calcined ironstone being red, raw limestone being grey, and coke black.

On either side of the centre column a distinct region of small ironstone and coke existed, and outside the column of small material, a further region of large material existed, similar to that shown in the centre column.

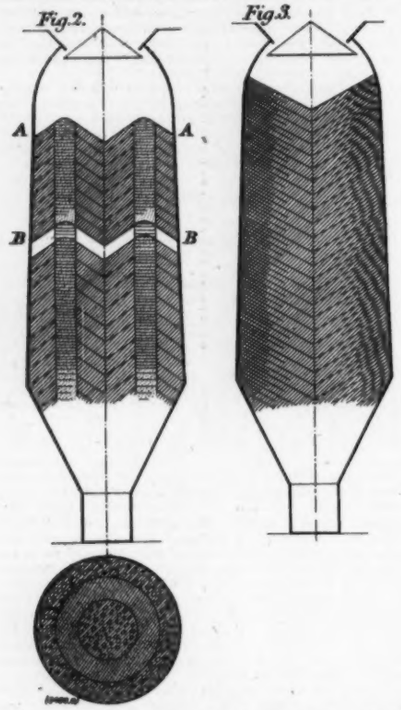
The material charged into the model had formed two distinct cones, the apex of each being 5 ft. from the wall of the furnace, corresponding with the size of bell (13 ft.). The depression of each cone was from 4 ft. 6 in. to 4 ft.

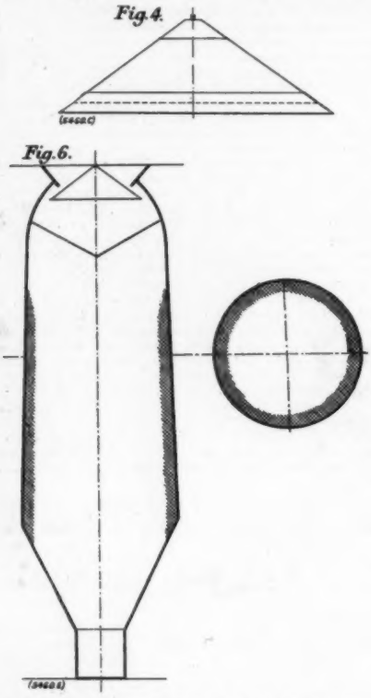
* Paper read before the Iron and Steel Institute on Thursday, May 2, 1918.

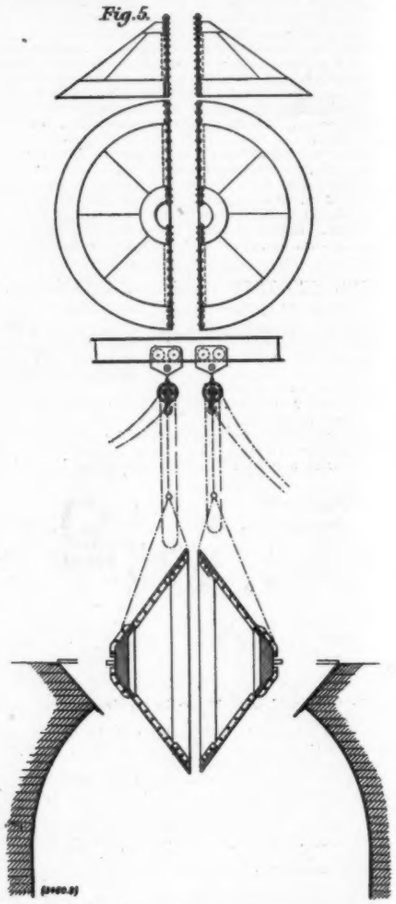
9 in., large material being very marked at the foot of each cone, so that the section across the model showed large material at each wall and in the centre, but two cones of small material in a direct vertical line from the apex to the bottom of the model.

The section when the furnace was full was as shown in Fig. 2 below, as A to A.

When the furnace was lowered and the model opened, the section of the lowered material was as B to B. The bell, equal to 13 ft. diameter in the furnace, was taken out of the model and another bell, equal to 15 ft. 6 in. diameter, was inserted, and material charged as in the previous experiment. When the model was opened the section was found to consist of lumpy material in the centre, the whole of the small ironstone and small coke being thrown against the wall. There was a much deeper inverted cone in the centre corresponding with the increased diameter of the bell. Material equal to 35 charges was then drawn from the bottom of the model and the burden fell 12 ft. It was found that the small coke and ironstone had descended close to the walls of the model to the entire depth down into the well of the furnace, the larger material descending in the centre of the cone, the material becoming smaller as it approached the walls of the model.







Experiments were made with various sizes of bell and deeper hoppers, the throat of the model being contracted to correspond with a smaller bell, filling being continued and drawing at the same time. These sections proved unsatisfactory.

The contracted throats were removed and the model restored to the original dimensions, the 15 ft. 6 in. bell being applied and the model recharged and drawing from the bottom at the same time. When opened the small was again found close to the walls down to the well of the furnace and large material in the centre, as before. Fig. 3, above, shows the form of bell which was finally decided upon. From the section shown in the model charged with a 13-ft. bell, it was apparent what was the cause of the irregular working of the furnace and the irregular quality of iron produced in 1881. It was clear the small coke and ironstone, which had formed the centre circular ring of denser material, throwing the larger ironstone and limestone against the walls of the furnace and into the centre column, had permitted the gases to ascend in the furnace in two distinct columns, and prevented the closer material being acted upon in the zone of reduction, so that it came down into the hearth of the furnace unprepared.

As new bells of the greater diameter could not be at once obtained, temporary expedient was resorted to. To increase the size of the old bells, wrought iron plates were riveted on to the rim of the 13-ft. bell in No. 1 furnace so as to increase the diameter to 15 ft. (See Fig. 4.)

In September, 1884, a new bell, 15 ft. 6 in. diameter, was fixed in No. 1 furnace, and in May, 1886, a similar bell was fixed into No. 2 furnace. These bells were made in halves so as to pass one-half at a time through the hopper for bolting together previous to riveting. (See Fig. 5.)

Owing to the fixing of these larger bells and the better distribution of material in the furnace the make of pig-iron for each furnace was increased from 23,135 tons in 1881 to 27,949 tons in 1883 and 30,936 tons in 1884, an increase of 20·7 per cent. with larger bell in one furnace, and an increase of 33·7 per cent., first year, with larger bell in both furnaces. This increased make of pig-iron was not due in any way to mechanical cleaning of ironstone, as no cleaning belt was existent at Skinningrove until several years afterwards. The ironstone smelted in 1881 to 1886 was from the same mine; limestone from the same quarry; the coke used being Pease's West quality.

During the same period the blast was heated by cast-iron stoves, maintaining a uniform heat from 900 deg. to 1,000 deg. F. These cast-iron stoves were afterwards replaced by firebrick stoves of the Cowper type, so that the coke economy, as between 1881 and 1886, was not due to any improvement in heating of the blast. The consumption of coke per ton of iron for 1881 during the period of the 13-ft. bell was 23·94 cwt.

From 1884 to 1886 it was exactly 22 cwt., a saving of 2 cwt. per ton of pig-iron. Considerable further economy of coke consumption resulted from the substitution of Cowper stoves replacing the old cast-iron ones, and for several years the coke consumption was maintained between 20 cwt. and 21 cwt. A low consumption of coke continued despite the gradual deterioration of Cleveland ironstone, which in 1886 averaged 27·94 per cent. of metallic iron, as against 26·17 per cent. in 1917, when larger quantities of limestone were required—15·73 cwt. per ton of iron as against 11·39 cwt. of limestone in 1886.

A comparative analysis of the slags in 1901 and 1917 confirms the extra limestone required to obtain a good working slag.

Average Analysis of Slags for 1901, 1902, 1903.

	Per Cent.
Silica	31·94
Alumina	23·95
Ferrous oxide	0·13
Manganese oxide	0·93
Calcium oxide	33·01
Magnesium oxide	8·50
Ratio $\frac{CaO}{SiO_2}$	1·03

Average Analysis of Slags for 1915, 1916, 1917.

	Per Cent.
Silica	32·15
Alumina	24·44
Ferrous oxide	0·26
Manganese oxide	0·93
Calcium oxide	32·52
Magnesium oxide	8·20
Ratio $\frac{CaO}{SiO_2}$	1·01

It is not difficult to determine the cause of the increased make of 33·7 per cent. of iron and the reduction of coke consumption by 2 cwt. per ton.

Owing to the better distribution of material in the furnace by use of bells of 15 ft. 6 in. diameter, instead of those of 13 ft., there was the entire disappearance of the two distinct cones whose apexes permitted large material to fall towards the furnace wall, and also into the centre of the furnace. For these two cones there was substituted one inverted cone whose diameter corresponded with the diameter of the larger bell, which threw the small mine and coke against the furnace walls, and this small followed the lines of the walls of the furnace as the burden descended to the tuyeres; also by directing the gases into one central channel instead of two separate channels, as shown in the model when using the small bell.

The saving of 2 cwt. of coke per ton of pig-iron is due entirely to the better distribution in the furnace by the increased size of the bell.

The long life of the furnace lining is undoubtedly due to the protection of the brick lining by the small coke and mine thrown against the walls of the furnace, giving less radiation through the furnace walls, the small burden acting as a thermos.

The immediate cause of blowing out No. 1 furnace in December, 1900, and No. 2 furnace in April, 1903, was the rupture of the furnace casings, which permitted the gases to percolate through to the firebrick lining and to fire on the outside of the shell. Both furnaces at the time they were compelled to be blown out for that reason, were working on as low coke yield and making as much iron as Nos. 3 and 4.

Had the furnace casing of Nos. 1 and 2 remained intact the lining would have had a longer life. When the old material was cleaned out from the well of No. 1 furnace, it was found that the dead small thrown by the larger bell against the walls of the furnace had been formed into a solid ring of carbonaceous material (Fig. 6) of the following analysis:—

Carbonaceous Lining from Blast Furnace.

	Per Cent.
Metallic iron and magnetic oxide ...	17·00
Silica	10·54
Ferric oxide	14·43
Alumina	7·88
Calcium oxide	7·65
Magnesium oxide	1·74
Carbonaceous matter	39·26
Alkalies	1·49

This ring extended for a considerable distance below the level to which the furnace was filled when blowing, and had not only greatly reduced the radiation through the furnace walls, but also, had it not been necessary to renew part of the brick backing for repairs to the furnace casing, would have enabled the furnace to be blown in on the original lining, after repairing the brickwork above the charging level.

THE BALDWIN WORKS LOCOMOTIVE OUTPUT.—The Baldwin Locomotive Works, says *The American Marine Engineer*, averaged nearly 10 engines a day during the year 1917, according to its annual report. These engines are valued at 63,000,000 dols., which, with other work, brought the total production of the plant up to 93,000,000 dols., as against 59,000,000 dols. the previous year, and more than seven times the aggregate sales in 1914.

THE FORMATION OF DIAMOND.*

By SIR CHARLES A. PARSONS, K.C.B., F.R.S.

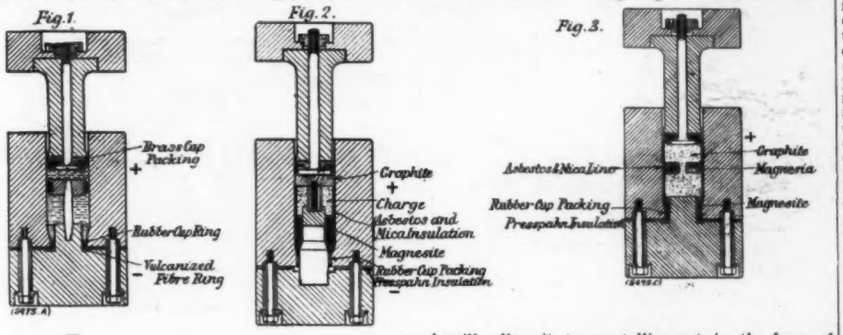
MANY theories have been advanced to account for the origin of diamonds, but I propose on this occasion to confine myself to what has been done in the way of systematic researches and investigations on this subject, and to consider whether it is possible to arrive at reliable and definite conclusions based on adequate foundations.

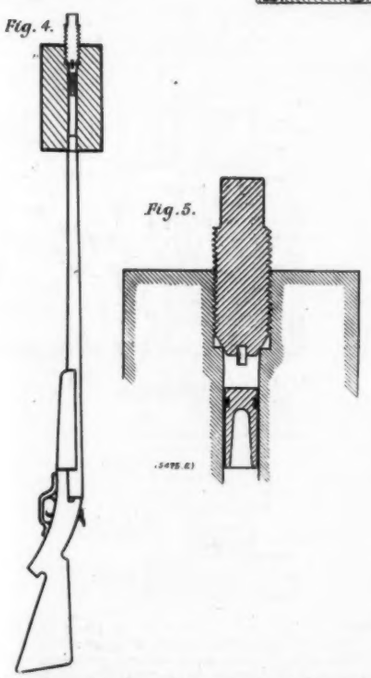
Henry Moissan must be accredited with having been the first experimenter to make, and to identify with certainty, genuine artificial diamonds. In the "Fours Electrique," published in 1897, his researches and experiments are very fully described in minute detail. He generously alludes to the previous experiments of Marsden, published in the Proceedings of the Royal Society, 1880–81, and says that he was the first to observe that if silver is melted in a carbon crucible and raised to the melting-point of steel, on cooling black diamond is sometimes found in the centre of the ingot. He, moreover, states that he has repeated the experiments of Marsden and found that when a small mass of silver is quickly cooled a satisfactory yield of black diamond results, but that transparent diamonds are never produced in silver.

Moissan further adds: "The work of Marsden is of the highest interest, because he observed quite correctly the great number of different crystallised products which may be formed at the solidifying point of silver when it gives up its oxygen, alumina, silica, silicide of carbon, &c." Moissan, in 1892, developed the electric furnace and applied it to his classical experiments which resulted in the production of minute transparent diamonds in small ingots of iron, and also of black diamonds in ingots of silver, when highly heated and quickly cooled in water or in chills. Moissan attributes the formation of the diamond in silver and also in iron to the compressive forces produced by the contraction of the outer layers and the dilation of the molten nucleus when setting.

What occurs in a mass of iron so treated, I propose to discuss at some length, and to lay before you evidence that the gases occluded in the metal are the real cause of the production of diamond and not the bulk pressure, as has been previously supposed. We shall see that the weight of diamond found in an ingot of iron has in one case reached one 20,000th part of the weight of the ingot, or about one 1,000th part of the carbon present—and that its quantity is of about the same order as the amount of carbon present as carbon monoxide occluded in the ingot.

Moissan expressed the opinion that iron in a pasty condition was the matrix of the diamond, and that great pressure was the determining factor, which compelled a minute fraction of the carbon present to appear as diamond, and in his experiments he further speaks of the probability of carbon being liquefied when under a pressure sufficient to prevent its volatisation, and that from the liquid state it may pass into the crystalline or rounded form on cooling. Crookes, in his lecture delivered before the British Association at Kimberley in 1905, emphasised the same view as to the probability of the crystallisation of carbon directly from the molten state on cooling. Crookes, in the same lecture, also stated: "It is certain from observations I have made, corroborated by experience gained in the laboratory, that iron at a high temperature and under great pressure—conditions existent at great depths below the surface of the earth—acts as the long-sought solvent for carbon, and will allow it to crystallise out in the form of diamond."





There is no *prima facie* reason against this view.

The calories evolved in the combination of graphite and oxygen are about half of 1 per cent. less than those evolved in the combination of diamond and oxygen, indicating that graphite at ordinary temperature is, to this extent, the stable state. The bulk pressure which has operated in some of our experiments, would, however, seem to have been amply sufficient to turn the balance in favour of diamond instead of graphite. The uncertainty on the other hand, as to the compressibilities and specific heats of the allotropic forms under high pressures and at high temperatures renders speculation of little value as to what may occur at the melting-point of carbon. All we know is, that up to the pressures and temperatures reached in our experiments no indication of a change from graphite to diamond has been produced.

I will now briefly describe some of our experiments which seem to bear most directly on the subject. Before doing so it is desirable first to describe the apparatus employed. The first experiments were made in 1886 to 1888 under an 80-ton press and with current supplied from a turbo-generator of 35 h.p.; the results were given in a paper to the Royal Society in 1888. The experiments were resumed in 1907 with a new equipment which consists of a 2,000-ton hydraulic press and a storage battery of 360 kw. normal output. The battery can be coupled for 2 volts, 4 volts, 8 volts, 16 volts, 48 volts, as required, and the mains and main switch can carry currents up to 80,000 amperes to the hydraulic press which is placed by itself in a small strong house, partly below ground, with walls of 2 ft. thickness reinforced with steel bars—the door is of steel, 3 in. thick—the roof is of light galvanised iron. The moulds under the press are further enclosed by 2-in. thick telescoping steel rings raised into position by steel ropes and counter-weights.

These precautions, as experience proved, were necessary as several violent explosions occurred which cracked the steel rings and blew off the roof. A charge of iron and carbon when confined and raised to a high temperature may be very violent if suddenly released by the melting of the pole pieces.

A steel mould of 9 in. diameter was first used, but smaller moulds of 4 in. and 2 in. diameter have given satisfactory experiments and are more easily and quickly repaired, and admit of higher pressures under the press.

We will first consider the experiments on carbon and compounds of carbon when heated under pressure by means of a central conducting core through which an electric current is passed.

Fig. 1 shows the arrangement chiefly for liquids; Fig. 2 for powders with or without liquids and gases; and Fig. 3 for melting carbon.

The result of treating benzine, paraffin, treacle, chloride and bisulphide of carbon, &c., under pressures up to 4,400 atmospheres resulted in the production of a soft coating of amorphous carbon on the heating rod, and when the current was very intense the carbon rod and the contiguous layer were transformed into graphite. In one experiment several pounds of carbon dioxide snow was added to the charge, which consisted of magnesia (Fig. 2), and was so arranged that evaporation of the heating carbon rod took place in an atmosphere of carbon dioxide and carbon monoxide under a gaseous pressure of 4,400 atmospheres, the condensate resulting being soft graphite. Upwards of 200 chemical reactions arranged to deposit carbon were tested under high pressure and central heating.

After each experiment samples were taken from various parts of the charge and carefully analysed for diamond, the methods of the analyses generally following those of Moissan and Crookes. Small residues of diamond occasionally occurred, but they appeared to be associated with the presence of iron in the charge, whether introduced intentionally or from the melting of the pole pieces, short circuits, or from other causes. On the whole there was no evidence that diamond had been produced by any of the chemical reactions, some of which were violent and caused explosions, and expanded the container. Some were endothermic, such as carborundum and sodium carbonate, which produced a grey solid which detonated.

We now pass on to consider the experiments designed to melt carbon in bulk, and I deal with them in some detail because so much prominence has hitherto been given to this aspect of the question. Fig. 3 shows the 4-in. moulds of gun steel used for this purpose.

The barriers used were composed of quicklime, marble, titanium oxide, or magnesia calcined in the electric furnace; of these magnesia gave the best results, being the more slowly converted into carbide. Intense heat was applied in one experiment for 5 seconds, but sufficient in amount to melt the graphite core six times over, the only result being a slight alteration of the structure of the graphite. Threlfall independently came to the conclusion from his experiments at about the same time (1907), that under 100 tons or 15,000 atmospheres pressure per square inch, graphite, electrically heated, remained graphite. It appeared, however, desirable further to investigate the possibility of carbon losing its electrical conductivity when approaching its melting-point, as alleged by Ludwig and others, and of shunting the current from itself on to the contiguous molten layers of the insulating barrier surrounding it. There had, however, been no indication of such a change having occurred, even momentarily; it rather seemed that the graphite core had been partially vapourised and condensed in the cooler parts of the charge. The experiment was, however, repeated with rods of iron and tungsten imbedded in the core, so that should the temperature of volatilisation of the metals under a pressure of 12,000 atmospheres exceed that necessary to liquefy carbon under the same pressure, the presence of these metals might produce a different result. No change, however, occurred, though in one experiment the pressure was raised to 15,000 atmospheres.

A different method of attack was then arranged which would ensure that carbon should be subjected to an extremely high temperature concurrently with high pressure, obtained by the rapid compression of the hottest possible flame, that of acetylene and oxygen, with a slight excess of the former to provide the carbon.

The arrangement was as follows (Figs. 4 and 5.):—

A very light piston made of tool steel was carefully fitted to the barrel of a duck-gun of 0·9-in. bore; the piston was flat in front, lightened out behind and fitted with a cupped copper gas-check ring, the cup facing forward; the total travel of the piston was 36 in. To the muzzle of the gun was fitted a prolongation of the barrel formed out of a massive steel block, the joint being gas tight. The end of the bore in the block was closed by a screwed-in plug made of tempered tool steel, also with a gas tight collar. A small copper pin projected from the centre of the plug to give a record of the limit of travel of the piston.

The gun was loaded with 2 drachms of black sporting powder, which amount had been calculated from preliminary trials. The barrel in front of the piston was filled with the mixture of acetylene and oxygen. It was estimated that this mixture would explode when the piston had travelled about half-way along the bore; when fired the piston travelled to within ¼ in. of the end as had been estimated, giving a total compression ratio of 288 to 1. As a result it was found that the surfaces of the end plug, the fore end of the piston, and the circumference of the bore up to ¾ in. from the end of the plug had been fused to a depth of about 0·01 in., and were glass hard, the surface of the copper pin had been vaporised, and copper sprayed over the face of the end plug and piston. The end plug, which had been hardened and tempered to straw colour, showed signs of compression, and the bore of the block for ¾ in. from the plug was enlarged by 0·023 in. in diameter, both indicating that a pressure above 15,000 atmospheres had been reached.

A little brown amorphous carbon was found in the chamber, which was easily destroyed by boiling sulphuric acid and nitre; there was no diamond residue from this. There was, however, a small crystalline residue from the melted layer of the end plug, from which was isolated one non-polarising crystal, probably diamond, but too small to identify with certainty. Considering the light weight of the piston and the short duration of the exposure to heat, the small diameter and volume of the end clearance space, the effects would seem to indicate that a very abnormal temperature had been reached, many times greater than exists in the chambers of large guns. There was, however, no evidence of any melting and recrystallisation of the carbon present. A calculation made by Mr. Stanley Cook, based upon the ratio of compression and a final pressure of 15,000 atmospheres, indicates that a temperature of between 15,250 deg. C. and 17,700 deg. C. was reached, the exact temperature depending upon the amount of disassociation or combination existing between the elements at the time.

It seemed desirable to try the effect of still higher pressures, so a rifle 0·303 bore was fitted with a specially strong breech mechanism by Rigby, capable of withstanding a charge of cordite 90 per cent. in excess of the service charge.

The gun (Fig. 6) was fixed with its muzzle 6 in. from a massive block of steel, in which a hole, 0·303 diameter, had been drilled to a depth somewhat greater than the

* Lecture delivered before the Institute of Metals, on May 2, 1918.

length of the bullet, and in alignment with the bore of the gun. Cylindrical bullets of steel with a copper driving band were chiefly used, shorter than the service bullet, and about one-half of the weight, some with cupped noses to entrain material, some with coned noses to match the bottom of the hole in the block. The velocity with 90 per cent. excess charge was estimated to be about 5,000 ft.-seconds. The substance to be compressed was placed, either at the bottom of the hole when a conical nosed bullet of mild steel was used, or over the mouth of the hole when a cupped-nose bullet of tool steel was employed.

About 100 experiments were made. The substances tested included graphite, sugar carbon, bisulphide of carbon, oils, &c., graphite and sodium nitrate, graphite and fulminate of mercury, finely divided iron and fine carborundum, olivine and graphite, &c. After each shot, the bullet and surrounding steel were drilled out, and the chips and entrained matter analysed. Fig. 7 shows the bullet in the hole after firing.

Several experiments were also made with a bridge of arc light carbon placed over the hole and raised to the limit of incandescence by an electric current, and the shot fired through it into the hole at the moment the carbon commenced to vaporise as observed in a mirror from without. Also an arc between two carbons was arranged just over the hole, and the shot fired through it (Fig. 8).

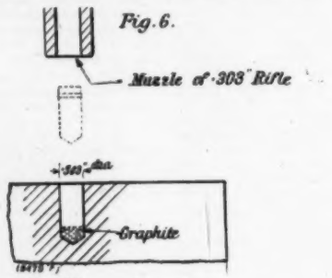


Fig. 6.

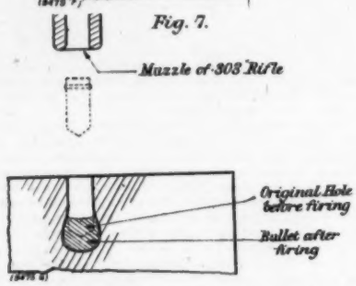


Fig. 7.

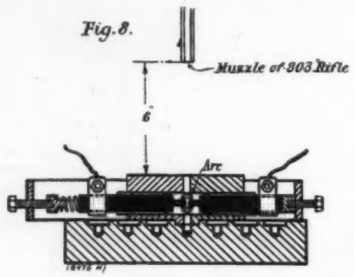


Fig. 8.

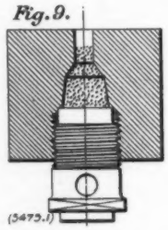


Fig. 9.

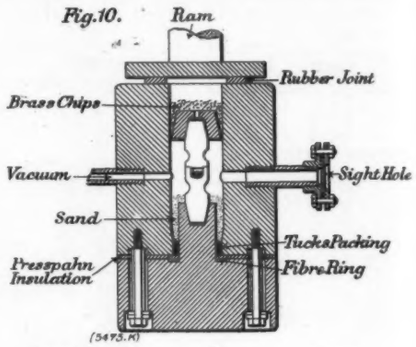


Fig. 10.

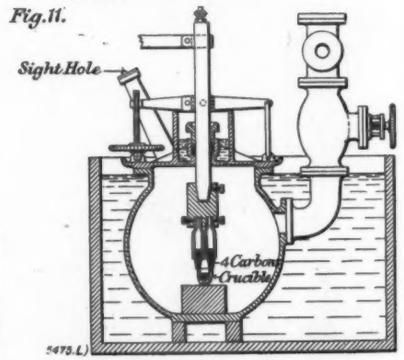


Fig. 11.

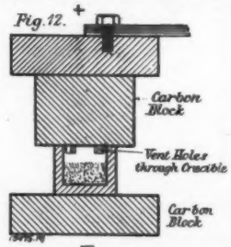


Fig. 12.

Of all the experiments only two yielded a reasonable amount of diamond residue, one made with graphite wrapped in tissue paper, the bullet, however, in this case having grazed the side of the hole, and thus producing some molten iron by the friction. The other, with the incandescent bridge, where again some molten metal would probably occur. The residues were, in all cases, exceedingly small, and not more than would be produced from a very small amount of iron melted, carburised and quickly cooled. There was no evidence of any incipient transformation of carbon in bulk into diamond that could be detected by analysis.

The pressure on impact of a steel bullet fired into a hole in a steel block which it fits is limited by the coefficient of compressibility of steel, and with a velocity of 5,000 ft.-seconds is about 2,000 tons per square inch. Measurements made from a section through the block and bullet (Fig. 7) showed that the mean retardation on the frontal face after the impact till it had come to rest was about 600 tons per square inch.

Several experiments were made by substituting a tungsten steel block, and a hole tapering gently from 0·303 in. at the mouth to 0·125 in. at the bottom. The mild steel bullet was deformed by the tapered hole and a greatly increased velocity imparted to the nose. Progressively increased charges were used, and even with relatively small charges the block cracked on the second round. With the 90 per cent. excess charge, the block always split, on the first shot, but this probably occurred after impact, and not till the full instantaneous pressure had been exerted, which was estimated to be greater than with the plain hole, probably exceeding 5,000 tons, a pressure about equal to that at the centre of the earth. In these latter experiments graphite was placed at the bottom of the hole. The analysis yielded nothing but graphite.

Experiments on Pressure in Cast-iron when Cooled.—It has been generally assumed that iron rich in carbon expands on setting, and that this supposed property is a contributory cause in the formation of diamond by increasing the pressure in the ingot.

We made several experiments by pouring iron saturated with carbon from the electric furnace through a narrow git into a very massive steel mould, closed at the bottom with a breech screw (Fig. 9). When cold the breech screw was easily removed, and there was no sign of there having been any appreciable pressure on the threads. Not being sure that, because of capillarity, the corners of the mould had been quite filled, a steel mandril was, immediately after pouring, forced down the git hole by a press giving a fluid pressure in the mould of 75 atmospheres. The observed pressure on the breech screw appeared not to have exceeded this pressure. Highly carburised iron, therefore, does not expand with any considerable force on setting.

The reason why a lump of cast-iron thrown into a ladle of molten metal first sinks to the bottom and soon rises and floats on the surface is probably that cast-iron is about seven times stronger in compression than in tension. Therefore when a sufficiently thick layer of the cold metal has been heated the interior is torn asunder by the expansion of the outer skin, and the specific gravity of the whole mass is diminished. We may, therefore, safely conclude that when iron is suddenly cooled, the only compressive bulk pressure that is brought to bear on the interior is that arising from the contraction of the outer layers after setting, and with highly carburised iron this can only be moderate because of the low tensile strength of the metal, and cannot exceed about 1,000 atmospheres.

Moissan observed that spherules or globules of iron with cracks and geodes never contained diamond. To such he attributed a loss of mechanical pressure. We now think that they merely provide an outlet for the occluded gases from the metal. We have made experiments by pouring highly carburised iron and alloys of iron on to iron plates, the cooling taking place from one side only, and under such conditions no diamond results; in fact, it only occurs when the ingot or spherule is cooled on all sides simultaneously so that a gastight skin is formed all over before the centre is cooled.

Since my paper to the Royal Society in 1907, the experiment of heating iron in a carbon crucible, and transferring it to a steel die and subjecting it to 11,200 atmospheres has been repeated, this pressure being many times greater than can occur in a cooled ingot, and it has been found that if the iron is allowed to set before the pressure is applied the amount of diamond is much greater than if pressed when very hot and while still molten, and that under the former condition it is about the same as when the crucible is cooled in water. The only reason that suggests itself to account for this is, that when pressure is applied, while very hot, some of the iron permeates the carbon of the crucible, and because of the greater specific heat and lesser conductibility of the carbon, the iron next to and in the carbon remains molten after the ingot has been cooled from the top by direct contact with the steel cup on the face of the plunger. Thus when cooling, the occluded gases have a free exit from the ingot through the molten metal (which is pervious to gas) into the carbon of the crucible, and are not retained in the ingot to the same extent as when it has set before pressing and is enclosed on all sides in an envelope of iron impermeable to the gases.

These experiments, I think, it will be agreed, dispose of the bulk pressure theory of the production of diamond in cooled iron. In fact, none of our experiments have shown that bulk pressure has any effect whatever on the production of diamond unless in so far as it may affect the amount and distribution of the occluded gases within the ingot. Several experiments were made to try the effect of extremely quick cooling by transferring a crucible with a charge of iron from the electric furnace to the press and submerging it in carbon dioxide snow, and also in water, at 6,000 atmospheres; the analysis showed very little diamond. Other experiments, where extremely quick cooling was effected not under pressure, confirmed the view that quick cooling as such is not a factor in the production of diamond and that carbon is not caught in a state of transition by quick cooling.

Experiments were made on oxidising alloys of iron by superheated steam after heating in the electric furnace. Large residues of crystalline oxides of the metals of the alloys resulted, as had been observed by Marsden in silver, and there also was a small percentage of the residue (about 5 per cent.) of very minute crystals which burnt in oxygen and had a specific gravity of 3·5, and are therefore diamond.

This part of the subject appears to merit further investigation.

Experiments under Vacuum.—The presence of diamond in some meteorites suggested a series of experiments under various degrees of vacuum up to the highest obtainable. It seems probable that in past ages some meteoric matter may have been melted by collision or ejected into space in a molten state and cooled by radiation, and that under such conditions absence, or diminution, of occluded gases might be a factor conducive to crystallisation of diamond.

More than 50 experiments were made with electrical heating of a carbon crucible under vacuum; Fig. 11 shows the first container used, which was evacuated to about ½ mm. of mercury by three steam jets in series with an air pump and jet condenser. This apparatus was subsequently replaced by a molecular air pump of very large capacity working in series with two other pumps, which could maintain an X-ray vacuum during the whole of an experiment. Fig. 12 shows the crucible in position. The suction outlet to the pump is 8 in. in diameter. When in this apparatus iron and alloys of iron were heated under high vacuum the large volume of gas given off by the metal was very striking, and unless the heating was very gradual much of the metal was ejected from the crucible. It became quite apparent from the experiments that metal ejects the occluded gases slowly and absorbs them slowly. It was remarkable that in no experiment under a vacuum higher than 2 mm. was diamond ever found in the ingot in the crucible, but it was found in the ejected iron which had not fully parted with its occluded gases. Here, again, we have impressed on us by these experiments that occluded gases are essential to the production of diamond in cooled iron. Experiments were made under low vacuum (Fig. 10) averaging about 1 in. of mercury, the gas in the container being 95 per cent. carbon monoxide. The heating up was prolonged, and the cooling was effected solely by radiation and convection, and was relatively slow, occupying 15 seconds from switching off the current to the setting of the metal. (Slides illustrated some of the diamonds produced in this way, the largest measuring 0·7 mm. in length.)

Let us for a moment recur to the experiments designed to impose the greatest possible bulk pressure on carbon and also on iron. The experiments designed to melt carbon have been carried up to 15,000 atmospheres steady pressure and to 300,000 atmospheres momentary pressure, which pressures are nearly up to the maximum

possible with the materials at our disposal. 300,000 atmospheres, or 2,000 tons per square inch, is about one-half the probable pressure at the centre of the earth; but only a fraction of one thousandth part of the pressure at the centre of large stars or also of the pressure produced by the impact of large bodies in space. By such collisions an intense heating and cooling, short or prolonged, of large masses might occur by the adiabatic compression of the central portions of the colliding bodies. Under such conditions the Moissan effect might be produced on a large scale, and if heating and cooling of iron are the only essential conditions, would result in the production of large diamonds. One source of diamond may therefore be attributed to prehistoric falls of meteorites. The artificial reproduction of such conditions is obviously beyond our reach. Up to the present, as we have said, the only proved source of artificial diamonds is from iron or silver intensely heated and then cooled with more or less rapidity.

I now pass on to further consideration of this question. We have seen that the evidence is very strong, or perhaps conclusive, that the occluded gases which escape on the setting of the metal and during cooling are a vital factor, and that unless such gases are retained within the ingot no diamond results.

We have further seen that great pressure on the metal when molten and cooling makes no difference in the yield, also that the retention of the occluded gases is, in this case, likewise essential. The experiments under vacuum have shown that if the metal has had time to lose its occluded gases no diamond occurs, so that we may conclude that under all bulk pressures on the metal, occluded gases are an essential factor.

Let us consider what happens inside an ingot or spherule when rapidly cooled simultaneously on all sides. It is first surrounded by a thin coating of solidified metal which below 600 deg. C. is nearly impervious to gases. As the coat thickens, layer within layer, more and more gas is ejected by the solidifying metal and is forced inwards, the diminishing nucleus of molten metal and its semi-solidified centre layer still pervious to gas receives the charge, and as this process progresses the pressure may rise higher and higher, though there may be a limit to the pressure against which the metal is able to eject gas when setting. All we, however, know is that the mechanical strength of the ingot or spherule places a limit of about 1,000 atmospheres to the gaseous pressure when concentrated into a small nucleus. In the case of some iron alloys which occlude more gas than iron, most of the spherules are split or shreded with an appearance consistent with this view. It would seem that the chief and only function of quick cooling in the production of diamond in an ingot or spherule is to bottle up and to concentrate into local spots within it, under high pressure, the gases occluded in the metal which during slow cooling would partially escape, while the remainder would become evenly distributed throughout the metal.

Crookes' microscopical examination of diamonds with polarised light, supports this view. I now quote a passage from his lecture at Kimberley in 1905. He says: "I have examined many hundred diamond crystals under polarised light, and with few exceptions all show the presence of internal tension. On rotating the polariser, the black cross most frequently seen revolves round a particular point in the inside of the crystal; on examining this point with a higher power, we sometimes see a slight flaw, more rarely a minute cavity. The cavity is filled with gas at enormous pressure, and the strain is set up in the stone by the effort of the gas to escape." Diamonds appear to be formed in the metal after it has set.

Moissan found that the diamond occurred near the centre of the ingot, and he remarks that natural diamonds must have been formed in a pasty matrix because they never show evidence of attachment to a hard body. But the most conclusive proof seems to be that we have found that a diamond is rapidly corroded by highly carburised iron just before setting, so that a microscopic diamond could not exist in molten metal for a second. On the whole, I think that diamond is probably formed at a temperature of about 690 deg. C., one of the points of recalescence, while the metal is still somewhat pervious to gases.

A heat treatment at high temperatures in the electric furnace appears to be essential, and it is probably required to form carbides, within the mass, other than those of iron, and which react with the occluded gases after solidification.

The view that carbon monoxide is the most important of the occluded gases is supported by the increased yield of diamond from iron which has absorbed much of this gas before cooling, as also by the fact of its combination with the metals and also with silicon and sulphur as carbonyls. Its remarkable action in association with iron on carborundum appears further to emphasise this view. In this connection Carpenter observed some years ago, that the gases given off from cast-iron at red heat under high vacua contained silica. We have seen that in rapidly cooled iron the occluded gases must be much compressed at the time the diamond is formed, and Mond has shown that pressure, in the case of iron, increases the yield of ferro carbonyl, and also is essential to the formation of the carbonyls of some other metals.

There is strong evidence to support the view that the action may take place solely between iron, carborundum, sulphur and carbon monoxide. It is, however, probable that other metals may also be involved, and that the action is one of great complexity. It must always be remembered that the yield of diamond is extremely small, and therefore very small traces of some of the elements may suffice to satisfy the action. Very little is, however, known and patient experimental research has here a most attractive field. As I have said, the largest percentage of diamond we found in cooled iron was estimated to be one 20,000th the weight of the iron and one 1,000th part of the carbon present, and if we assume that the iron contained a volume of carbon monoxide equal to 0·69 of the volume of the ingot (a common proportion) the weight of carbon in the carbon monoxide exactly equals the weight of diamond. The yield of diamond from the South African Blue Ground of the De Beers Mine, in 1904, was one 5,400,000th of the weight, so that the yield from cooled iron in the best experiment has been 270 times greater.

I am not disposed to speculate, but may venture to suggest that it would seem probable that if a large mass of iron, alloyed with other elements was submitted to suitable heat treatment, and after setting, but when still at a temperature permeable to gas, was subjected to carbon monoxide at a pressure of about 1,000 atmospheres, for a long time, that segregations might take place slowly within the mass, and diamonds in payable quantity and size might be produced. This experiment virtually consists of replacing the cold metal envelope, thrown around the ingot, by a gaseous envelope at a superior pressure, which will not only imprison the occluded gases, but further, by the ingress of additional gas into the metal may induce the formation of diamond throughout the whole of the ingot. It may be found that higher gaseous pressures than those permissible in a cooled ingot may increase the yield, and if this is found to be the case they can be easily applied.

In rapidly-cooled iron there is a steep temperature gradient in the metal, but when under gases at high pressure it seems probable that the natural tendency to segregation on slow cooling may suffice to determine the local concentrations which form diamond.

The presence of crystals of silica, alumina and magnesia and the spinels and pyrope, &c., associated with diamond in rapidly cooled iron alloys, and also when oxidised by steam, appears to have a bearing upon the presence of similar crystals generally found in association with diamond, and merits further investigation. The solution which I have indicated appears to be compatible with the conclusions of Bonney that eclogite is the parent-rock of the diamond in South Africa. He says: "Thus the diamond has been traced up to an igneous rock. The 'blue ground' is not the birthplace either of it or of the garnets, pyroxenes, olivine, and other minerals, more or less fragmental, which it incorporates. The diamond is a constituent of the eclogite, just as much as a zircon may be a constituent of granite or a syenite. Its regular form suggests that it was the first mineral to crystallise in the magma." The solution we have suggested also accounts for so small an amount of carbon having escaped oxidation, for according to our view both the diamond and the eclogite have been crystallised in iron at comparatively low temperatures.

It is possible that there may be other feasible solutions to the problem. For instance, it is possible that at a suitable temperature carbonic oxide under high pressure might cause diamond to crystallise in olivine, blueground, or eclogite, if some of the constituent elements were present as metals and carbides, with some it would form carbonyls and with others it would react.

On this supposition, no molten iron matrix is required, and the diamonds would be formed in blue ground itself at an earlier stage of its formation while at a red heat and before hydration, deep down in the earth under high gaseous pressure. The field is wide and complex, and reliable landmarks have been difficult to locate. Now, however, as I hope, a reliable path has been found, progress should be more rapid in the future.

In conclusion, I desire to express my obligations for kind assistance and advice to Sir Dugald Clerk, Professor Jeans, Mr. Stanley Cook, Mr. Campbell Swinton, and to many other friends, as also to Mr. H. M. Duncan, who has acted as my assistant and analyst, and has given valuable help in the collection and tabulation of the whole of the experiments; lastly, to Mr. Van Mopez and to Mr. Hirsh and Professor Liversidge, who have kindly lent me most of the diamonds.

FOOD INVESTIGATION BOARD AND COMMITTEE.—A committee has been set up by the Food Investigation Board of the Department of Scientific and Industrial Research to consider engineering and physical problems which arise in connection with the use of cold to preserve food, and to organise such research on these subjects as may be considered necessary. The committee is under the chairmanship of Sir Alfred Ewing, K.C.B., F.R.S. The terms of reference are designedly wide so that its activities may be as little hampered as possible. They cover refrigerating machines and the insulation of cold stores in general, and in particular the application of refrigeration in ships, barges and railway vans for the conveyance of produce at low temperatures, and the methods of measuring the temperature and degree of moisture in closed spaces. The committee may be said to be taking up work at the point at which it was left by the Refrigeration Research Committee of the Institution of Mechanical Engineers, but with greatly extended terms of reference. That committee, which was also under Sir Alfred Ewing, was appointed to define a standard in refrigeration, and the valuable results of its deliberations were issued as a report of the Institution in October, 1914. The present committee includes engineers with much experience in the practical work of refrigeration, and also physicists familiar with the methods of experimental research which are likely to be relevant. Their work will be helped forward by suggestions received from without, and the committee would welcome suggestions as to specific questions on which further knowledge is needed. Any communication should be addressed to the Secretary, Sir Alfred Ewing's Committee, Scientific and Industrial Research Department, 15, Great George-street, Westminster, S.W. 1.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, May 3, at 6 p.m., at the Institution of Civil Engineers, Great George-street, S.W. The paper on "War Work of Women on Munitions Production in Engineering Shops," by Mr. Ben. H. Morgan, announced for the last meeting, will be read and discussed, and the discussion on Miss Monkhouse's paper on "The Employment of Women in Munition Factories" will be concluded.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, May 3, at 7.30 p.m., at 39, Victoria-street, Westminster, S.W. 1. Lecturette: "Power Plants: National, Communal, or Industrial," by Mr. W. A. Tookey, M.I.Mech.E.

THE SURVEYORS' INSTITUTION.—Monday, May 6, a paper on "The Metric System in its Relation to the Surveyors' Profession," will be read by Lieutenant A. J. Martin (Fellow). The chair will be taken at 5 p.m.

THE SOCIETY OF ENGINEERS.—Monday, May 6, at 5.30 p.m., in the Apartments of the Geological Society, Burlington House, Piccadilly, W. A paper (illustrated by lantern slides), entitled "Modern Shipbuilding and Economy in Material," will be read by Mr. J. W. Isherwood, M.I.N.A.

THE JUNIOR INSTITUTION OF ENGINEERS: NORTH-EASTERN SECTION.—Tuesday, May 7, at 7.15 p.m., at the Mining Institute, Neville-street, Newcastle-on-Tyne, paper on "Critical Speeds of Shafts," by Mr. G. Bonner.

THE FARADAY SOCIETY.—Tuesday, May 7, at 5.30 p.m., in the Rooms of the Chemical Society, Burlington House, Piccadilly, London, W. 1, general discussion on "The Co-ordination of Scientific Publication." The discussion, which will be of an informal character, will be opened by Sir Robert Hadfield, Bart., F.R.S., President.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH LOCAL SECTION.—Tuesday, May 7, at 7.30 p.m., at the Rooms, 207, Bath-street, Glasgow. Informal discussion on "The Proposed Regulations for Electrical Equipment of Ships." Opened by Mr. J. F. Nielson.

THE RÖNTGEN SOCIETY.—Tuesday, May 7, at 7.45 p.m., at the Royal Society of Arts, 18, John-street, Adelphi, W.C. Discussion of the proposed new Rules of the Society.

THE ROYAL SOCIETY OF ARTS.—Wednesday, May 8, at 4.30 p.m.:—Ordinary meeting: "The Rubber-Planting Industry," by Mr. John B. Farmer, D.Sc., M.A., F.R.S., F.L.S., Professor of Botany, Imperial College of Science and Technology. Sir Edward Roseling, Chairman of Council, Rubber Growers' Association, will preside. Thursday, May 9, at 4.30 p.m.:—Special Lecture: "The Freedom of the Sea," by Sir Francis Taylor Piggott, M.A., LL.M., Chief Justice of Hong Kong, 1905-12. Lecture II.—"The Freedom of the Sea in War." Lord Sanderson, G.C.B., K.C.M.G., will preside.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, May 8, at 7.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C., Mr. J. B. Hoblyn will read a paper entitled "Commercial Steels and their Heat Treatment."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, May 9, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Discussion on "A British Electrical Proving House." Introductory paper by Mr. C. Turnbull, Member.

THE CONCRETE INSTITUTE.—Thursday, May 9, at 6 p.m., at Denison House (close to Victoria Station), when a paper will be read by Mr. A. Alban H. Scott, Vice-President of Architects, on "Reinforced Concrete Ships," with lantern illustrations.

THE OPTICAL SOCIETY.—Thursday, May 9, at 7 p.m., at the Imperial College of Science, South Kensington. "A Note on Spherical Aberration," by Naval-Instructor T. Y. Baker, R.N., and Major L. N. G. Filson, R.A.F.

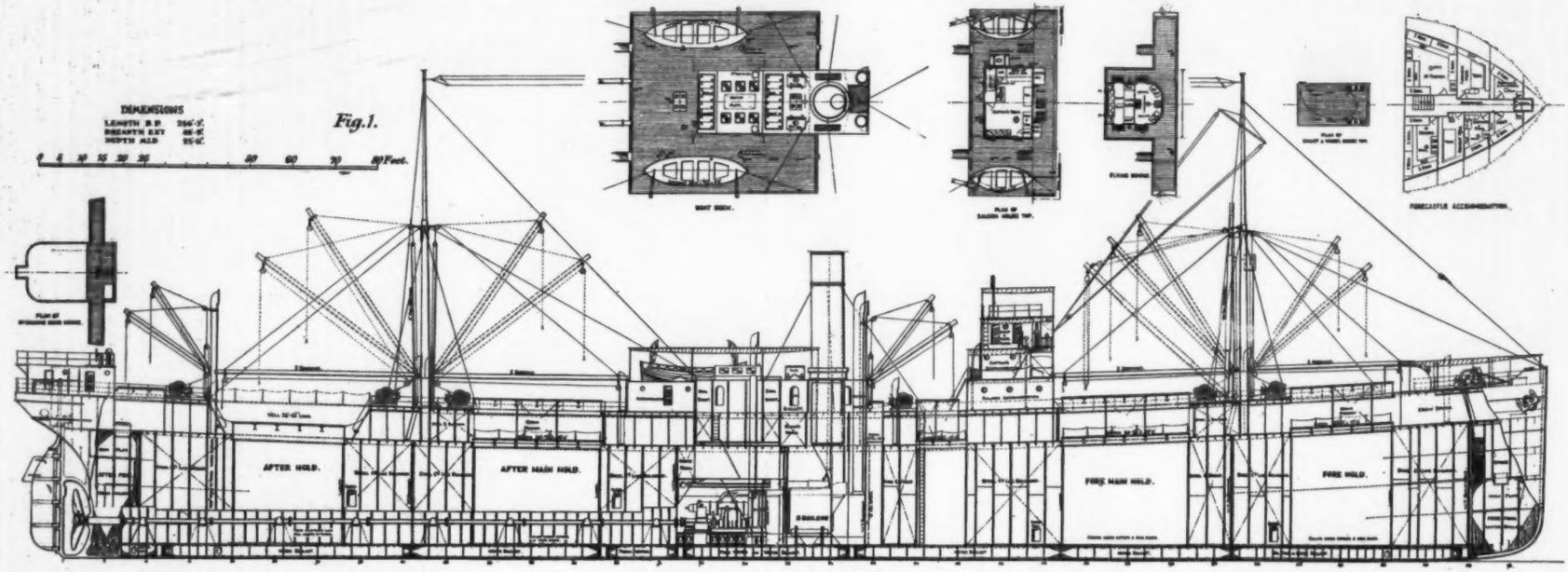
THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, May 10, at 5.30 p.m., a discourse will be delivered by Professor F. Gowland Hopkins, M.B., D.Sc., F.R.S. The subject will be "Human Nutrition." Afternoon Lectures, at 3 p.m.:—Tuesday, May 7: Professor Arthur Keith, M.D., F.R.S., Fullerian Professor of Physiology at the Royal Institution, on "Craniologists" (Lecture III). Thursday, May 9: Sir J. G. Fraser, LL.D., on "The Folk-Lore of Bells" (Lecture I). Saturday, May 11: Dr. W. L. Courtney, on "Dramatic Realism" (Lecture I). Monday, May 6, general meeting, 5 p.m.

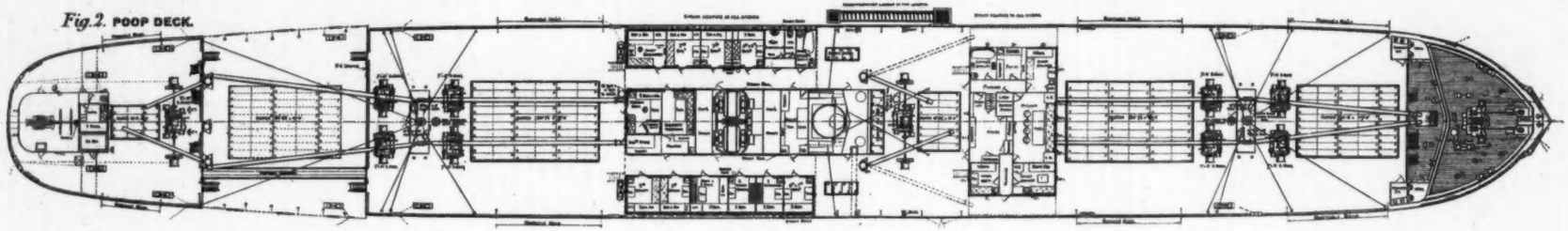
THE ROYAL SANITARY INSTITUTE.—Friday and Saturday, May 10 and 11, at 5 p.m. and 10 a.m., in the Assembly Rooms, Town Hall, Hereford. The Members will be welcomed by His Worship the Mayor of Hereford (Mr. E. R. Dymond, J.P., Assoc.M.Inst.C.E.) and Councillor Moore (Chairman of the Health Committee), when discussions will take place on Friday, May 10, at 5 p.m., on "Tuberculosis: Its Treatment and Present Position," opened by Mr. Dryburgh Gold, M.D., D.P.H. (M.O.H., Herefordshire C.C.); "Notes on the Cultivation of Lands Order, 1918, with Special Reference to Land Drainage," by Mr. G. H. Jack, M.Inst.C.E. (County Surveyor, Herefordshire C.C.) Saturday, May 11, at 10 a.m., on "Cost and Construction of Workmen's Dwellings, Roads, Sewers and Water Supply in Connection with Town Planning," by John Parker, M.Inst.C.E., F.S.I. (City Surveyor, Hereford). The chair will be taken by Professor A. Bostock Hill, M.D., M.Sc., D.P.H. (Member of Council).

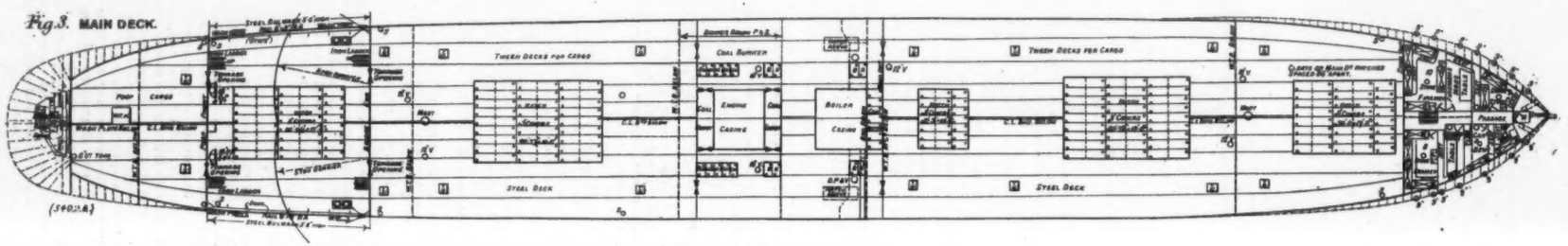
THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON): LEEDS CENTRE.—Saturday, May 11, at 3.30 p.m., at the Philosophical Hall, Park-row, Leeds, when Mr. H. N. Gresley, of the Great Northern Railway, will deliver his Inaugural Presidential Address.

THE S.S. "WULSTY CASTLE" WITH LJUNGSTRÖM TURBO-ELECTRIC PROPELLING MACHINERY.

(*For Description, see opposite Page.*)







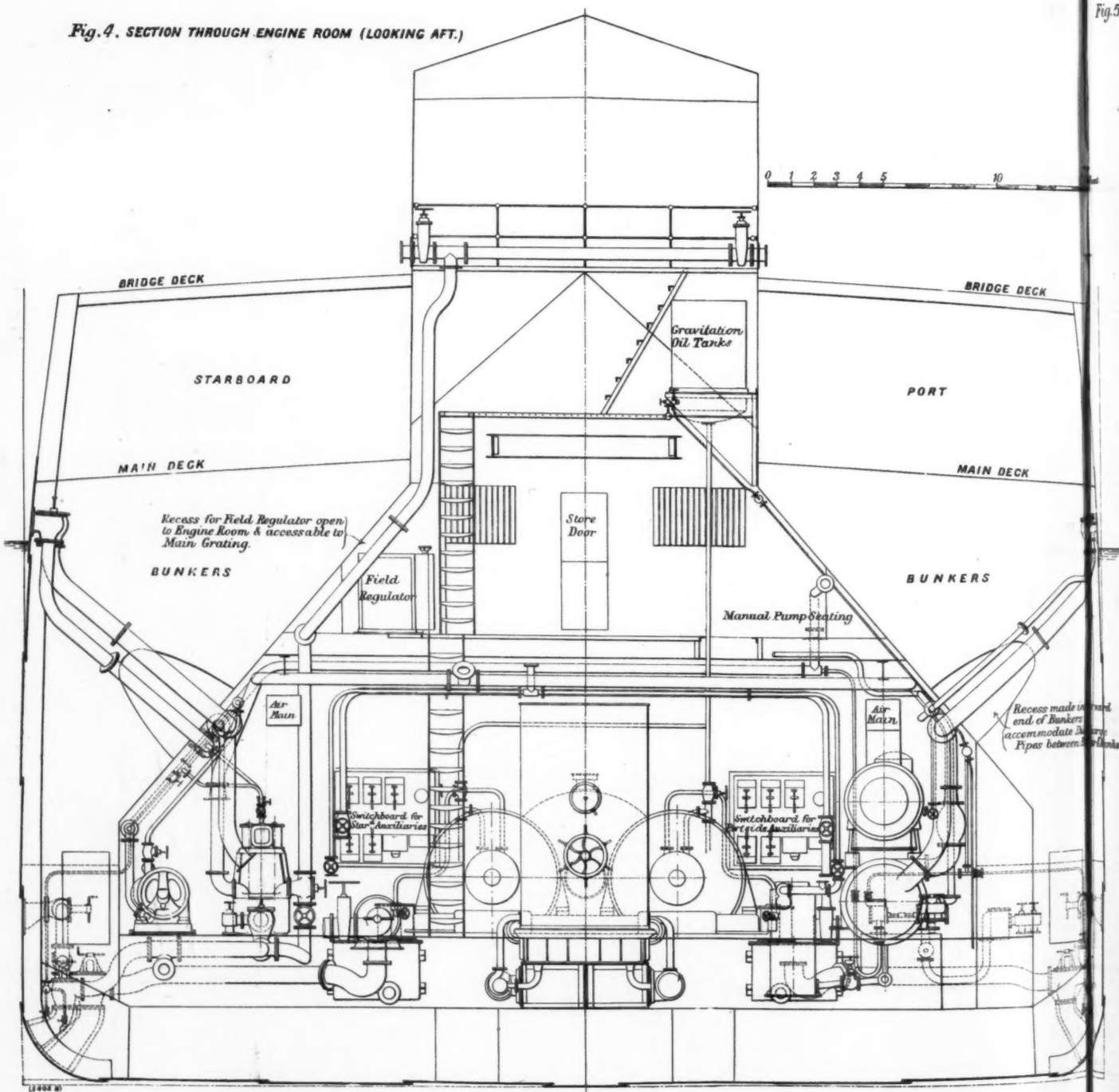
GENERAL ARRANGEMENT OF LJUNGSTRÖM TURBO-ELECTRIC PR

THE BRITISH LJUNGSTRÖM MARINE TURBINE

(For Description see Page

Fig.5

Fig. 4. SECTION THROUGH ENGINE ROOM (LOOKING AFT.)

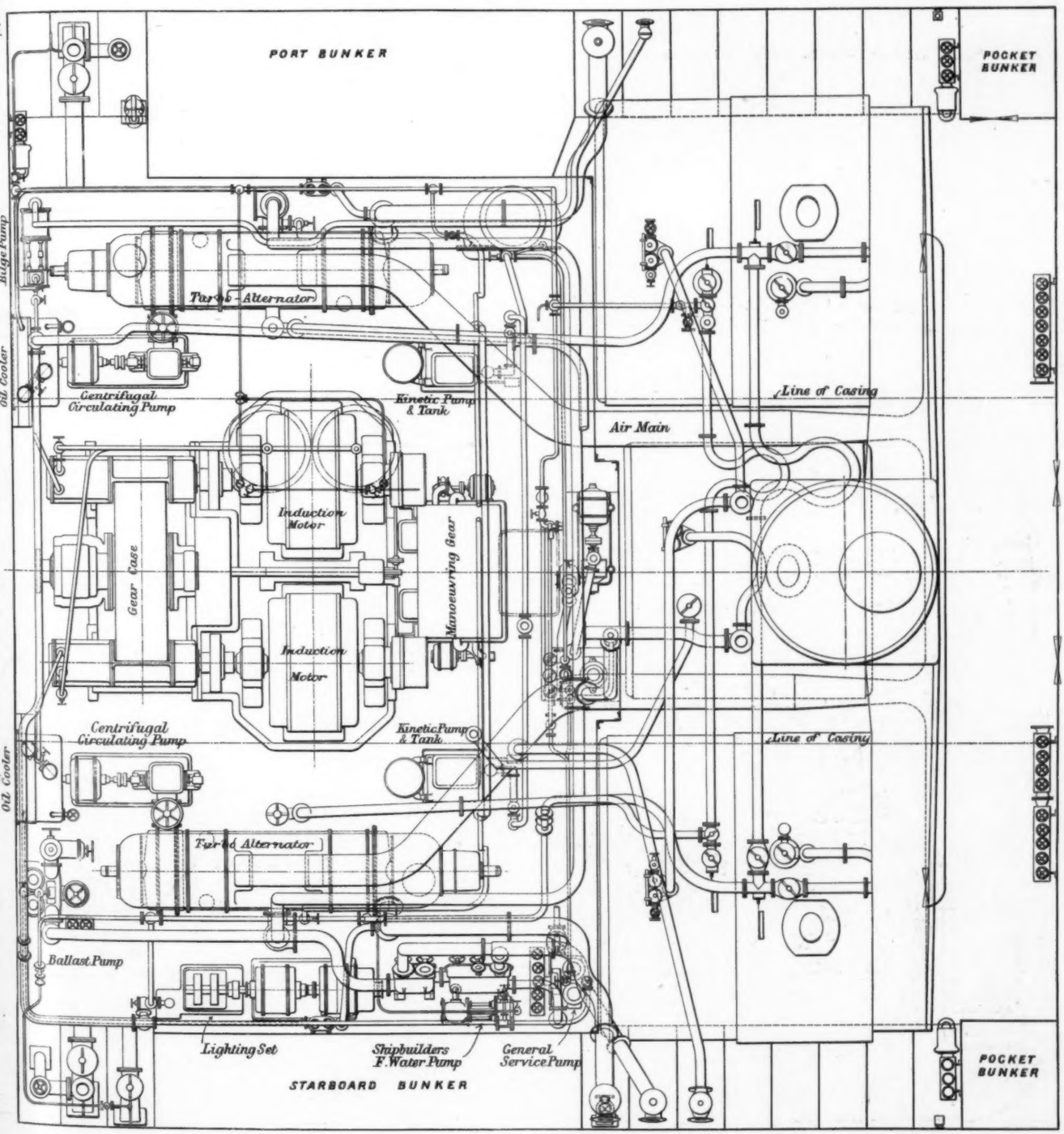


PROPELLING MACHINERY FOR THE S.S. "WULSTY CASTLE."

MARINE TURBINE COMPANY, LIMITED, LONDON.

(Description on Page 489.)

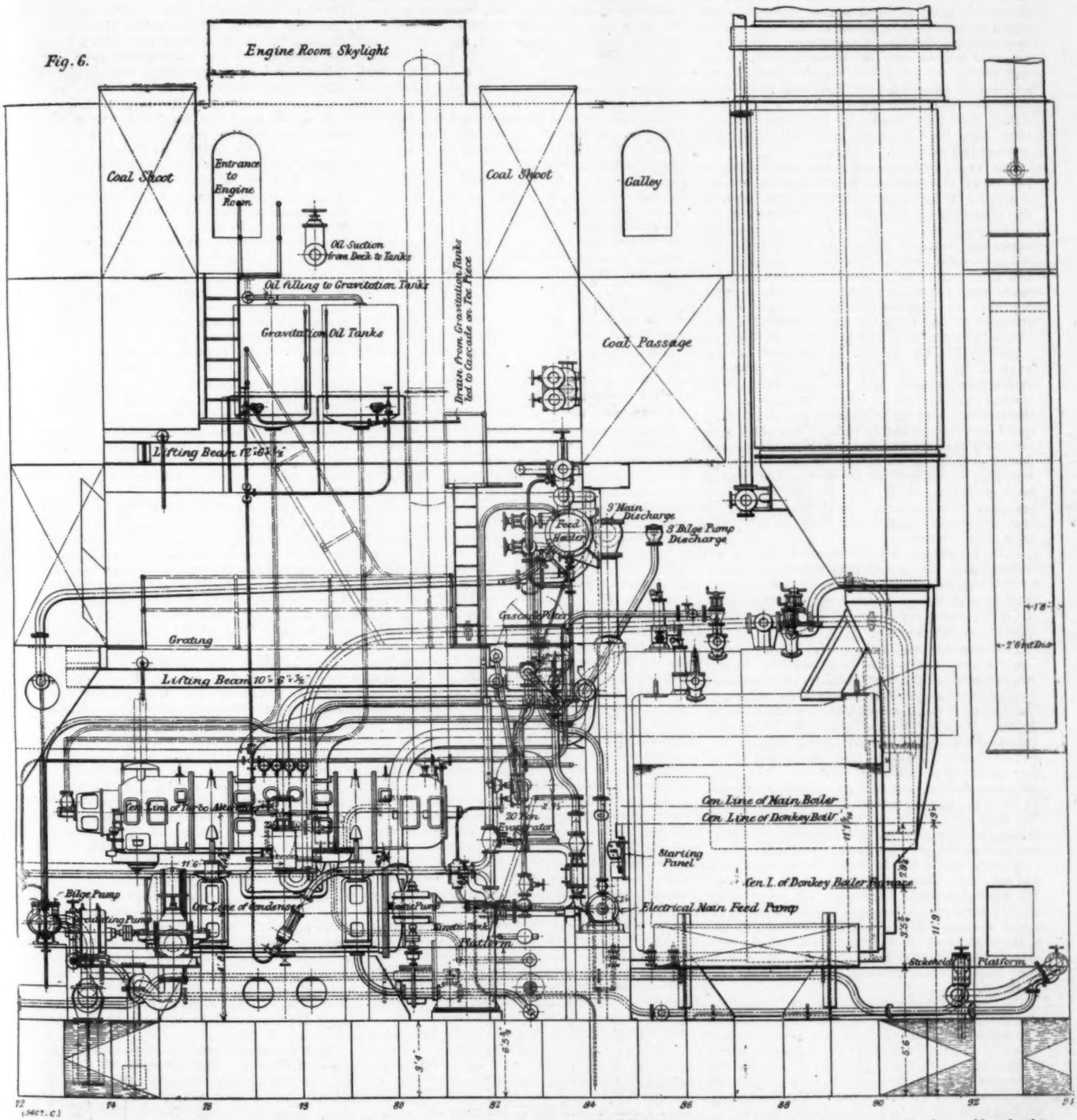
Fig. 5.



LJUNGSTRÖM TURBO-ELECTRIC SHIP-PROPELLING MACHINERY.

THE BRITISH LJUNGSTRÖM MARINE TURBINE COMPANY, LIMITED, LONDON.

Fig. 6.



LJUNGSTRÖM TURBO-ELECTRIC SHIP-PROPELLING MACHINERY.

MUCH has been written regarding steam turbo-electric ship propulsion, and decisive steps towards its application have been taken particularly in the United States of America where the adoption of the system for an immense battle cruiser demonstrates the great confidence in its potentialities following upon practical experience in a large collier. But little data of a thoroughly practical nature have been available for two or three years, and we propose, therefore, to deal very fully with the first seagoing ship fitted in this country with the Ljungström system, the trials of which took place this week on the North-East Coast. This system, introduced by two Swedish engineers whose names it bears, proved highly efficient in a Swedish coasting steamer, and Ljungström turbo-alternators are finding a rapidly increasing application in land power stations ranging from 1000 k.w. to 35,000 kw. In this country Sir William Beardmore, Bart., with characteristic enterprise, took the initiative in connection with marine work, forming the British Ljungström Marine Turbine Company, Limited, who are responsible for the first British marine installation, and have contracted for a number of merchant ships, the Ljungström machinery for which varies from 1000 s.h.p. to 6000 s.h.p. Already this type of machinery contracted for totals 102,000 s.h.p. for 45 British, American, and Scandinavian vessels.

Before entering upon a detailed description of this first set, it may be useful to indicate briefly the principle of the Ljungström turbine, which is the feature of the installation. It differs materially from the type of reaction machine now commonly in use, the aim being to increase the relative speed of the reaction blading in order to achieve a closer approximation to that theoretically desirable. In an ordinary reaction turbine half the blades are mounted on the fixed casing and half on the moving

drum. If the casing were rotated backwards at the same speed as the drum rotates forward, the relative velocity of the drum blades to the casing blades would be doubled, and a close approach to the best theoretical ratio of blade speed to steam speed would be commercially feasible. There are obvious mechanical difficulties in embodying this idea in an axial flow turbine, but the difficulties, though still serious, are less if the flow be radial. By the exercise of great ingenuity and originality, these difficulties have been surmounted by the Ljungströms and some remarkably low steam consumptions have been recorded with turbo-generators built on this principle.

The Ljungström turbine consists essentially of two series of concentric blade rings, each series connected to its respective supporting disc and the two rotating in opposite directions. Each blade ring is connected to its disc through a dumb-bell sectioned expan ion ring, the other end being free. The steam is introduced into the turbine at the centre and flows out radially between the two series of blade rings, which consequently rotate the supporting discs in opposite directions. Each disc is attached to an alternator rotor. In a 7,000-kw. turbo-alternator, each disc has 19 blade rings, the largest ring being 33½ in. in diameter and the smallest 5¾ in. For its output the turbine is extraordinarily light and compact, and as the method permits of a close approach to the theoretically best ratio of blade speed to steam speed the efficiency is very high. The turbine being extremely symmetrical and the blade rings supported on an ingenious system of expansion rings, very high superheats can be used without danger from distortion arising from inequalities of temperature. Further, since where the temperature is high the steam speed is low, there is little risk from blade erosion.

In the installation, with which we are dealing, two turbo-electric alternators supply electric current to two motors, which drive the single propeller shaft through double helical single-reduction gear, the motors being capable of driving the ship ahead or astern at full power.

The vessel into which the system has been fitted —s.s. Wulsty Castle—has been built by Messrs. John Blumer and Co., Sunderland, for the Lancashire Shipping Company, Ltd., managed by Messrs. J. Chambers and Co., Liverpool, the consultants being Messrs. William Esplen and Son, Liverpool. Elevation and deck plans are given on page 488, and as they are complete little description of the ship structure is called for. The length between perpendiculars is 356 ft. 3 in., breadth external 48 ft. 9 in., and the moulded depth 25 ft. 11 in. The ship is of the three-island type, with poop, bridge and forecastle, and the machinery is accommodated amidships. The vessel is designed to carry cargo only, and it will be noted that the fore main and aft main holds are fitted with grain feeders. The winch equipment is adequate for the handling of the main cargo, and consists of ten 7 in. by 10 in. steam winches. All the other particulars relative to the bunkers, the coal shutes, and the steel centre line bulkhead in the main holds will be entirely clear from an examination of the illustrations reproduced.

The general arrangement of the propelling machinery is illustrated by the cross-section through the engine-room, and the plan of engine-room and boiler room, both on Plate XLVI, and by the longitudinal section of the engine-room, showing the turbo-generator set, on page 489. For the present we will deal only with the lay-out of the machinery, leaving until later detailed description and illustration of the units of the machinery.

Steam is generated in two cylindrical boilers of 13 ft. internal diameter by 11 ft. long, with 3 in. internal diameter smoke tubes, giving a combined heating surface of 3,600 sq. ft., and designed for a working pressure of 220 lb. per square inch. The boilers are worked under the Howden system of forced draught, and an interesting feature with this installation, is that the necessary air for combustion is supplied to the boiler furnaces by fans incorporated in the alternators of the Ljungström turbo-alternator sets. The air is drawn from the engine-room, thus ventilating the machinery space, passes through the alternator and cools the windings, and, in its warm state is then passed to the heaters of the Howden forced draught arrangement. In this way, the usual fans associated with the Howden forced draught system are not required, and, furthermore, when the turbo-alternators are stopped no steam is required from the boilers, so that the control becomes more or less automatic. The boilers are fitted with Schmidt smoke-tube Trafford Park superheaters, capable of superheating steam to a total temperature of 625 deg. F., measured at the turbine stop valve. The superheating surface is 50 per cent. of that of the boilers. Retarders are fitted in those boiler tubes which have no superheater elements, ensuring even velocity of the gases through all the smoke tubes. Each boiler has two Deighton type furnaces of 3 ft. 7½ in. internal diameter with firebars 5 ft. 9 in. long, which latter are of the Trident type, in one length. The boilers have the usual mountings, including diamond blowers for cleaning the superheater tubes when underway, and also with Silley's smoke-box doors.

In the boiler rooms a Crompton ash hoist is fitted with a self-tipping bucket in addition to the usual hand hoist. In addition to the two main boilers, a small donkey boiler on the centre line, supplies saturated steam at 100 lb. pressure for working the winches and other auxiliaries in port. In other respects the boiler-room arrangement may be said to represent standard mercantile practice.

As to the general installation of the machinery, the electric motors and reduction gearing are, of course, in the centre, with the manœuvring gear on the starting platform ahead of them. The turbo-alternators are on each side. They are of the standard Ljungström type, and each set develops 625-kw. three-phase current at 650 volts 60 cycles per second at 3,600 r.p.m., with 180 lb. steam pressure at inlet, 95 per cent. vacuum, the temperature of the cooling water being 70 deg. F. The bedplate for the turbine is formed by the condenser as shown in Fig. 6. Each condenser has 1,150 sq. ft. of cooling surface, and is of the three-flow Contraflo type. The two main induction motors are coupled to the propeller shaft through double helical gearing made by the Power Plant Company, Limited, West Drayton, and are together capable of delivering the 1,500 shaft horse-power continuously at sea with a propeller speed of about 76 r.p.m. The stators are wound with single bars per slot, and insulated with seamless mica tubes, the end connections being of heavy copper strip. The rotor windings are of the cylindrical-barrel type. Each motor is ventilated by its own fan, which is mounted on the rotor spider. The main bearings are of the pedestal type with split spherical bushes, and are arranged for forced lubrication. The brush lifting and short-circuiting gear are mounted on the forward end of the motor shafts, and are operated by handle interlocked with the starting hand-wheel. The shop tests gave an efficiency of 95 per cent. at full load, the corresponding power factor being 0·875. The turbo-alternators, condensers, main motors, auxiliary motors and manœuvring gear were manufactured by the Brush Electrical Engineering Company, Limited, Loughborough, to the specifications of the main contractors—the British Ljungström Marine Turbine Company, Limited, under the supervision of Messrs. Esplen.

The auxiliaries are, for the most part, electrically driven, and in this connection reference should be made to the two electrically-driven centrifugal circulating pumps, each driven by three-phase, 60-cycle motors, at 650 volts and about 1,750 r.p.m. There are two air pumps, one being of the kinetic type, with the condensate and kinetic pumps embodied in the one casing, each combination being driven by a three-phase, vertical motor at about 1,470 r.p.m. Both circulating and air pumps are supplied by the Pulsometer Engineering Company, Limited. The electrically driven feed pump is of the turbine type, supplied by the Power Plant Company, and is capable of feeding both boilers at full power. It is driven by a three-phase motor at 3,540 r.p.m. An auxiliary-driven feed pump by Clarke, Chapman and Co., intended for harbour use, can be connected to the main feed discharge to supply the boilers, as a standby. The boilers are fed through a feed heater designed by the Contraflo Condenser and Kinetic Air Pump Company, and the necessary steam for this purpose is tapped from the main turbines and drained to the kinetic tank. The soda pumps, for circulating the electrolyte, supplied by the Pulsometer Engineering Company are mounted on the manœuvring gear and are driven by alternating-current motors at about 1,600 r.p.m. These will be referred to later in connection with the manœuvring gear. The electric lighting set is of the combined type in which a direct-current 18-kw. generator may be driven either by a three-phase motor or by a de Laval steam turbine, the three units being mounted on one shaft with a suitable disconnecting clutch. In harbour the set is driven by the 25-b.h.p. turbine whilst at sea the motor takes its current from the main generating set. In addition to supplying the electric lighting set and wireless plant, this set is capable of exciting both propelling turbo-alternators.

For ballast and general service purposes two duplex pumps are fitted in the engine-room, a further pump being installed for fresh water purposes. A small donkey boiler is fitted between the two main boilers for use in harbour, and is designed to work at 100 lb. pressure with saturated steam. The deck winches are driven by steam, but should electric winches be fitted at some future date, no additional generator plant will be required, as one of the main propeller sets running at one-eighth of full load will serve, and even at this low fraction the consumption is only 18 lb. per kw. hour. The control panels for the electrically-driven auxiliaries and the lighting set are situated on the after engine-room bulkhead.

The auxiliary condenser is of the Contraflo non-vacuum type, capable of taking the exhaust from the deck machinery and harbour auxiliaries. It drains to a cascade filter, fitted with the usual bye-pass and float control to the feed pumps, this plant being of the Richardsons–Westgarth type. A 20-ton Morison's evaporator is installed in the engine-room, and is so arranged that the feed supply may be taken from one of the auxiliary pumps, or from the sanitary tank.

On page 492 we give three perspective views of the turbo-alternators in the Brush Company's works at Loughborough. Fig. 7 illustrates the complete port turbo-alternator and condenser ready for despatch from the workshop. The exciter, auxiliary oil pump, and tank, are clearly shown; also the regulating valve with the governor gear and relay oil pipes. The two pull handles for resetting the emergency governor can also be seen. The latter governor operates when a speed of 10 per cent. above the designed rate has been exceeded. The condenser has a mild steel body with a cast steel exhaust branch riveted thereto, on which is bolted the complete turbo-alternator.

Fig. 8 shows the complete turbine lifted out of the exhaust casing. The special gear provided, allows the turbine to be rotated on one or both of two axes. This facilitates inspection and handling. Locking pieces are provided to secure both halves of the turbine and prevent any relative movement. In each turbine there are 39 rings, of which 20 are on one rotor, and 19 on the other rotor. The external diameter is 28 in. and overall length 17½ in., the total rotating weight being only 4 cwt.

Fig. 9 illustrates one of the turbo-alternators in course of erection. The left-hand end shows the space for the governor, oil pump and tank. Both governor and main oil pump are driven by the gear shown on the shaft-end. The auxiliary oil pump is steam driven, and is mounted on the projection of the oil tank beyond the air inlet handle. This pump comes into action should the main oil pump break down. It is also used for starting-up the plant. The steam chests are in place, and show the grooves on the fixed labyrinth disc. These chests are coupled by a breeches pipe to the main stop valve, which is controlled by the governor through an oil relay. In the valve shown there is incorporated the steam separator, strainer, stop and throttle valves. At one end of each alternator rotor is a fan which, in addition to ventilating the machine, also provides, as already stated, the necessary air

for combustion in the boiler furnaces. One of these four fans is indicated on the right-hand side, close to which is also seen the slip rings. The turbo-alternator is supported on the condenser by the exhaust branch. There are also four columns resting on springs, but these are free to move vertically and axially as the set expands. The machine is thereby only held at the flange of the exhaust branch. There are two of these turbo-alternators in the ship.

(To be continued.)

INDUSTRIAL NOTES.

MR. GEORGE TERREL, K.C., speaking in the House of Commons on April 25, in the debate on the annual statement of the Minister of Munitions, said: "I think the Minister of Munitions was a little ungenerous in his statement in not recognising that the work accomplished was not really his work, but the work of a class whom he omitted to mention or notice in any way whatever—the manufacturers. I wish, as representing certain manufacturers' associations, to say that they have had their business interfered with, interference with their men, they have been harrassed with inspectors and the filling-up of vast numbers of unnecessary and difficult forms. I deny most positively that they have been profiteers. I know in some cases a charge can be made but the Auditor-General reports that evidences of large profits are not numerous. The Ministry have so often gone wrong because they have always, from the time the Ministry was instituted, refused to consult employers. Their ears have always been open to labour, but to the employers who, after all, have a greater and wider experience than the amateurs at the Ministry, they turn a deaf ear. The late Minister, Dr. Addison, after receiving a deputation of employers, consulted them for a time and they advised him, but their reports were invariably turned down. The present Minister, Mr. W. Churchill, consulted certain organisations, but when it comes to consulting the great body of employers he has always refused, and still refuses, to be guided by any advice they offer. Some of the reports on industrial unrest state that excessive Government interference is one cause of unrest. The Ministry has never understood the reasonable demand of skilled labour for higher pay than unskilled labour; they have never left the employers to deal with their workpeople, but have always interfered and made unnecessary trouble. In the contemplated Bill for the restoration of trade union rules Mr. Churchill has consulted the trade unions and is going to act, apparently, without consulting the employers. It is unfair and unjust to the employers who are doing their best to help the country, and my object in rising is to make a vigorous protest against the policy which is being pursued."

The Minister of Munitions announced, in the course of his speech on April 25, a new scheme for controlling the employment of skilled labour. It is an entirely new departure, of far-reaching possibilities, and employers should give it very close attention. We reproduce Mr. Churchill's remarks on the subject from the official Parliamentary report:—

"We have now reached the point where I must make a further appeal for greater facilities in regard to the movement, to places where they are most needed, of the skilled workmen who are left at home. I propose, shortly, to issue an appeal to workmen generally, pressing them to enrol as War Munition Volunteers, so that the available residuum of skilled and efficient labour which we have in this country can be moved from point to point as the needs of the time require, and so that all are employed to the highest possible advantage. It is clear that war munition volunteers who have undertaken to place themselves so fully at our disposal are of greater value from the point of view of indispensability to munitions output than those who have not volunteered for this special form of munitions service. Side by side with this it will be necessary to regulate and restrict the action of employers so as to prevent the uneconomic use of labour and to enforce dilution by preventing new men being engaged and by requiring in some cases the dismissal of men who are already employed. Unless that process can be carried out we shall find increasing difficulties as we continue progressively to release our skilled men for military service. I have consulted, and I am still in consultation with the Trade Union Advisory Committee, and I have received a great encouraging measure of support from them. With this greater power over the mobility of labour, on which a definite and formal statement will be issued in the course of a few days, I am hopeful, by pursuing our well tried methods of substitution, that we shall continue to strike the happy mean between the needs of the army in men and its no less vital needs in munitions."

The Home Office has had under consideration the question of the provision of seats in shell factories for the use of women and girls employed in turning and machining, who have to do their work standing. Opportunities for taking occasional rest occur either during the work itself or in intervals between the conclusion of one operation and the commencement of the next, or on unexpected occasions when the supply of material runs short or the machinery breaks down; and in many shell factories seats are provided to enable the women and girls to avail themselves of these opportunities. The Home Secretary accordingly proposes, with the concurrence of the Minister of Munitions, to make an Order in pursuance of Section 7 of the Police, Factories, &c. (Miscellaneous Provisions) Act, 1916, requiring facilities for sitting to be provided for all female workers employed in any process in turning or machining shells or shell bodies, so as to enable them to take advantage of any opportunities for resting that may occur in the course of their employment. The Order as drafted does not prescribe the precise nature or amount of the provision to be made. This would be left to be determined according to the circumstances of the particular case.

Any objection to the proposed Order must be sent to the Secretary of State at the Home Office, Whitehall, London, S.W. 1, within 21 days after the date (April 26) of the notice. The objection must be in writing, and must state: (*a*) The specific grounds of objection, and (*b*) the modifications asked for. Where an objection is made jointly on behalf of a number of occupiers, the names of the occupiers and their addresses must be stated, or, if the objection is made by an association of occupiers on behalf of its members, the number of members affected by the Order.

The Iron and Steel Trades Central Advisory Committee (Operatives) held their fourth meeting at the Employment Department at 10.30 a.m. on Friday, April 26. The committee considered, among other matters, the principles upon which the wages to be paid to discharged and disabled sailors and soldiers should be fixed and the best method of dealing with resettlement generally by means of trade sub-committees in connection with the Local Advisory Committees attached to the Employment Exchanges.

Labour delegates from all parts of the country were present at a meeting held in London on Wednesday, April 24, of the National Federation of General Workers, with a view to discuss questions arising out of the Whitley Report, under which it is proposed to form Industrial Councils for the settlement of trade disputes and for the general improvement of industrial conditions. The following resolution was passed, stating: "That, while in favour of the main principle of the Whitley Report, this federation can only recommend its acceptance on the understanding that trade unions as such are represented on any committees that may be set up, and that shop, district or other national machinery established shall not supersede the authority of the trade unions concerned."

It was, moreover, decided to appoint a committee consisting of one representative of each society affiliated in the federation to draft a detailed report on the various points in the Whitley Report for submission to the annual meeting in August next.

The discussion showed that opposition would be made to any proposal for establishing new methods of negotiations between employers and their workpeople in individual factories. A further point on which the council were unable to accept the Whitley recommendations was in connection with the proposal that the organisation of the workers should be based on lines not of craft, as at present, but of industry. The object of this proposal was to secure that all the workers in any one industry should be incorporated in one organised union, irrespective of their specific craft. So far as the General Workers' Union was concerned, the proposal was declared to be impossible of adoption owing to the fact that the general worker moved from one industry to another according to the state of employment. But notwithstanding these reservations, the attitude of the council was entirely favourable to the Whitley Report.

Mr. Alexander Wilkie, it is announced, has stated that the Admiralty have practically accepted the Whitley Report and that it will be put into force in the Royal Dockyards. The workmen will thus, he added, be able to have a voice in the conditions under which they work and in the fixing of their remuneration.

In their special number, dated February, entitled, "A Thousand and One Uses for Gas," the British Commercial Gas Association, 47, Victoria-street, London, S.W. 1, deals with the work done by women within the gas industry during the past two years or so. The variety of the jobs entrusted to them is really astonishing; many of these, such as ordinary navvying, trucking coal, handling tar barrels and breaking up spent oxide, would before the war have been deemed quite beyond their capacity. The number is profusely illustrated. Free copies of the issue can be obtained on application to the Secretary of the Association.

The Government has already expressed its approval of the proposals put forward in the Whitley Report that in each industry which has reached a sufficient level of organisation there should be established a Joint Standing Industrial Council consisting of equal numbers of representatives of associations of employers and trade unions. The Ministry of Labour has been entrusted with the duty of assisting industries in carrying into effect those proposals. A large number of such councils is already in process of formation; but in certain industries, owing to various reasons, progress has as yet been slow. In the latter industries, pending the establishment of Industrial Councils, the Ministry of Reconstruction has undertaken, in association with the Board of Trade and the Ministry of Labour, to promote the formation of Interim Industrial Reconstruction Committees consisting of equal numbers of representatives of organisations of employers and trade unions. What form these organisations should take must depend on the circumstances of each industry. What functions the committee should assume and what they should leave or delegate to existing organisations or to specially created bodies, are also questions which must be determined by those concerned. But it is not intended that the Interim Industrial Reconstruction Committees, any more than the permanent Industrial Councils, to which it is hoped they will lead, should confine themselves to the consideration of subjects specially referred to them by a Government Department. It is hoped that they will exercise a large initiative in devising means by which the transition from war to peace conditions may be most smoothly effected, and the way opened to the rapid restoration of industrial enterprise.

The most urgent questions to which the attention of Interim Industrial Reconstruction Committees should be given are indicated below. It is desired specially to emphasise the importance of those relating to the promotion of industrial organisations and to the questions of employment and supplies of raw materials which are the cardinal factors in industrial reconstruction:—

(1) The promotion of industrial organisation; (2) demobilisation and employment; (3) raw materials; (4) priority; (5) financial facilities; (6) new industries; (7) the disposal of surplus Government stores. In addition to the above points, which will become of importance immediately upon the cessation of hostilities Interim Industrial Reconstruction Committees are urged to invite the co-operation of trade organisations in considering other matters of a like kind which may affect the commercial and manufacturing needs of the trade and industry in the reconstruction period.

PERSONAL.—The rapid expansion of the business done by the W. J. Crouch Company, steel exporters, 253, Broadway, New York, has necessitated their taking larger and better-equipped quarters than those now occupied. They have leased for a period of years, the whole of the fifteenth floor at 68, William-street, corner of Cedar-street, New York, where they are now located.

HONOURS FOR NAVAL ENGINEERS.—The *Supplement to the London Gazette*, dated the 26th ult., announced that the following honours have been awarded, with the approval of His Majesty the King, to members of the engineering branch of the Navy, among others:—For services performed in difficult circumstances and during a long period in British submarines operating in the Baltic Sea: To receive the Distinguished Service Medal: Engine-Room Artificers Charles Bateman, J. D. C. Bonham, J. H. Bowles and Hiram Wilson. Mentioned in Despatches: Chief Engine-Room Artificer John McDougall, Engine-Room Artificers J. W. Brand and E. A. White. For services in action with enemy submarines: To receive the Distinguished Service Cross: Engineer-Lieutenant Walter Clare, R.N.R. To receive the Distinguished Service Medal: Engineman T. J. Lyons. For operations on the Belgian Coast: To be a Companion of the D.S.O.: Engineer Lieutenant-Commander Henry Baker, R.N.R. To receive the Distinguished Service Medal: Chief Engine-Room Artificers G. J. Burn and R. Nelson. Mentioned in Despatches: Chief Artificer Engineer John Wright, Chief Engine-Room Artificers Thos. Brooks, George Carter and W. C. Smith and Engine-Room Artificer Edgar Hooper. The King has approved of the following awards to engineers in the mercantile marine. To receive the Distinguished Service Cross: Third Engineer L. C. Henry. Commended for services: Chief Engineers Robert Murray, N. P. Robertson, Herbert Squires, and Harold Sutherns, and Second Engineer Arthur Fleming. His Majesty the King of the Hellenes has conferred the Order of the Redeemer upon Engineer-Commander H. O. Andrews, R.N., and Engineer-Lieutenant R. G. Knox, R.N.

LJUNGSTRÖM TURBO-ELECTRIC SHIP-PROPELLING MACHINERY.

THE BRITISH LJUNGSTRÖM MARINE TURBINE COMPANY, LIMITED, LONDON.

(*For Description, see Page* 489.)

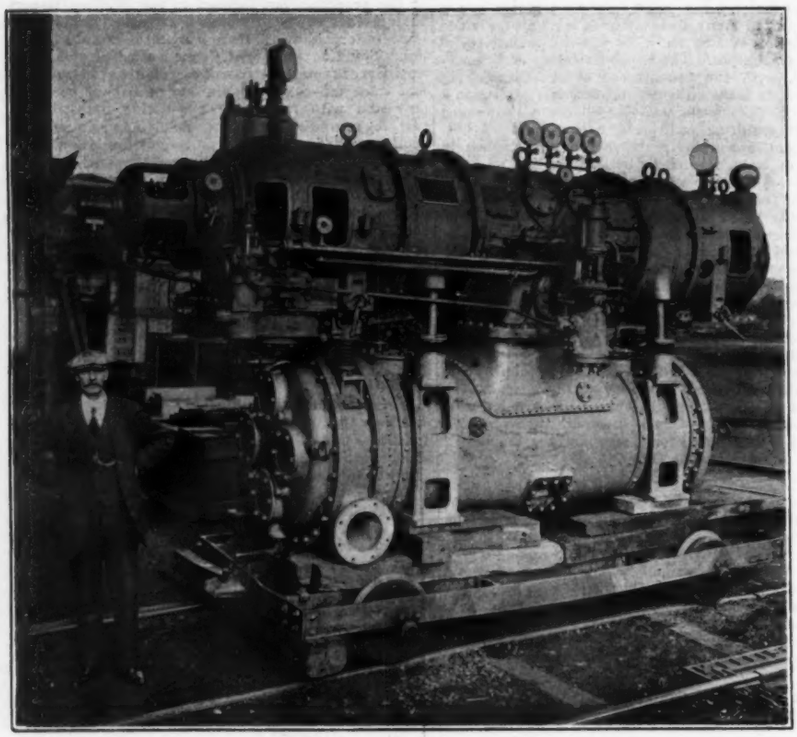


Fig. 7. Turbo-Alternator and Condenser.

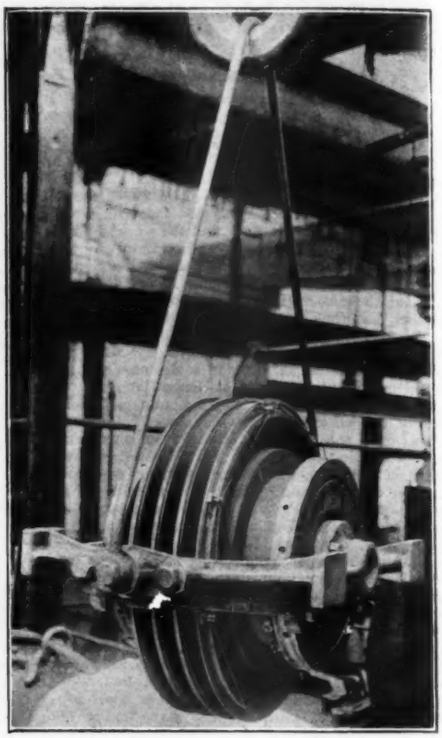


Fig. 8. Turbine withdrawn from Casing

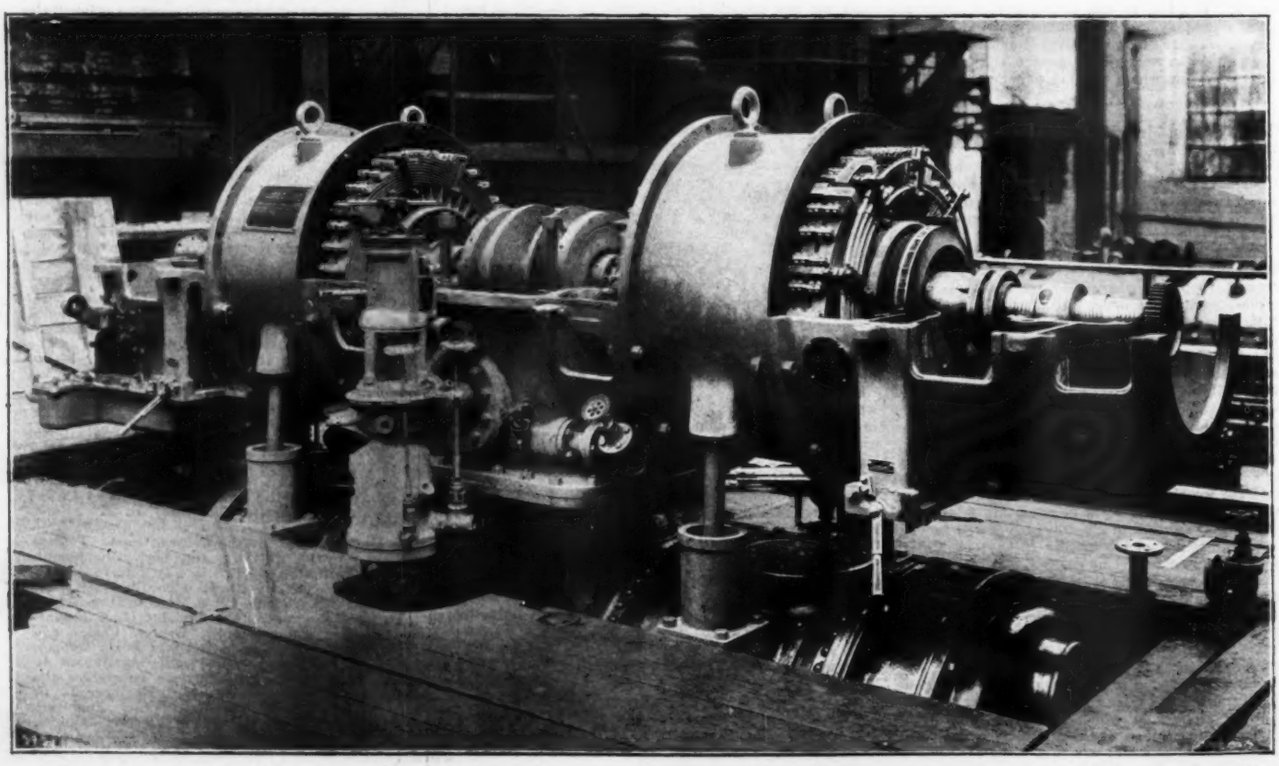


Fig. 9. Turbo-Alternator in Course of Erection.

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TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8568 GERRARD.

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With a Two-Page Plate of the GENERAL ARRANGEMENT OF LJUNGSTRÖM TURBO-ELECTRIC PROPELLING MACHINERY FOR THE S.S. "WULTSY CASTLE."

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 487.

ENGINEERING.

FRIDAY, MAY 3, 1918.

POST-WAR COMMERCIAL AND INDUSTRIAL POLICY.

THE committee appointed by the Government, with Lord Balfour of Burleigh as president, to consider post-war commerce and industrial progress with special reference to the resolutions passed at the Economic Conference of the Allies in Paris, completed their report in December last, but publication was delayed in order that the Dominion Government authorities might have an opportunity of studying it. The report, now issued, does not indicate the nature of its reception by the overseas Dominions. That, however, will no doubt be rectified at the forthcoming conference of representatives of all the units of the British Empire. Meanwhile, the document itself, in view of its comprehensive scope, is worthy of careful study. It cannot be said to throw much new light on the problems considered, but it crystallises, and states with notable moderation, authoritative opinions on many subjects now engaging wide attention. The Committee's main object has been, as stated, to lay down the general lines of policy upon which they think that permanent provision should be made, in the light of the experience of the war, for the safeguarding and promotion of British industry and commerce in the future.

Lord Balfour's Committee have had the advantage of the reports of separate committees set up for the consideration of each of the principal trades. A most interesting part of the Final Report is the summary of the decisions of these committees. The conclusion of the Committee on the Iron and Steel Trades is that the relatively stationary condition of our industry in respect of production and its declining position in the world's trade is due in part to the deficiency of our natural resources in iron ore, but primarily to the more modern character, better organisation and greater efficiency of the German and American industries, in respect alike of the acquisition and development of supplies of raw materials and of production and distribution. Here, as in other industries, bulk production has had a great effect. According to the latest peace statistics available the annual output of pig-iron by our blast furnaces ranged from 33,300 tons to 65,000 tons, as compared with 80,000 tons and 135,000 tons in the States and from 45,700 tons to 67,400 tons in Germany. In America large corporations, and in Germany, the Stahlwerkverband, greatly influenced improvement in the trade, and, as will be shown later, corresponding developments in this country are strongly advocated. In the engineering trade, again, kartels and the rebate system have greatly helped German competition, in association with low railway rates for export, low freight rates, intelligent assistance of German official representatives abroad, a liberal system of credit, cheapness of manufacture on a large and standardised scale, a businesslike method of selling and adjusting goods to the needs of customers, and the advantages of liberal, specialised education—all of which methods, it is declared, "should be well within the compass of British manufacturers." Here, again, combinations, in the direction of specialised and bulk manufacture, are advocated, but it is further pointed out that our engineers have been somewhat handicapped in the past by the shipping lines. Shipping conferences, involving the great lines of the world, British, German and French, have had the effect of nominally limiting competition between those lines by establishing theoretically equal rates of freight, but in practice the British manufacturer has been placed at a disadvantage. There should therefore be, in the opinion of the Engineering Trades Committee, some restriction as to the right of British owners, for some time at least, to enter into working agreements with the present enemy. In connection with the shipbuilding trade report it is admitted that, before the war 43 per cent. of steel forgings delivered to shipbuilders and marine engineers in 1912-13 were of foreign origin, the greater part being German, and that in many cases the prices which involved this extensive importation were "dumped" prices. The Shipbuilding Trade Committee express the opinion that in the case of rough machine forgings and finished crankshafts, the dumping was governed by political considerations, "the object being to cripple the British forgemasters, with a view of reducing the potential output of guns and other war materials." This committee also favour greater co-ordination among shipbuilders and marine engineers and the effective promotion of progressive standardisation in all directions.

As regards the electrical trades, the committee responsible for their investigation recommend a thorough reform of the legislation and regulations in force in the United Kingdom as to the generation and distribution of electricity in this country, and also the promotion and operation of light railways. They favour the prohibition of the importation of enemy goods for a period of three years after the war except in certain cases, the prevention of the sale in the United Kingdom of any imported electrical goods at prices lower than those quoted in the country of origin and the imposition of import duties sufficiently high to protect efficiently the electrical industry. The State departments, public bodies and companies supplying electrical energy are to accept only British tenders. Combination among manufacturers and official co-operation with such action are also commended. This committee, like others, refer to the unsatisfactory and ill-regulated working conditions, arbitrary restriction of output, and opposition to the use of labour-saving machinery, resulting in a serious diminution of output. As regards non-ferrous metals, the committee charged with reporting on this trade recommend Government financial assistance for the development of copper refining in the United Kingdom, and formulate proposals for Government action in regard to the securing of the supplies of lead and the promotion of the production of aluminium, with a protective tariff on all imported refined lead and manufactures of lead and reductions thereof, with free importation within the British Empire.

Having summarised the conditions in the more important trades, Lord Balfour's Committee lay stress on the general rise and extension of long-established manufactures, with the exception of the iron and steel trades, and they make the recommendation that the importation of goods of enemy origin, at present prohibited, should not be continued, subject to licences in exceptional cases, for a period of at least twelve months after the conclusion of peace, and subsequently for such further period as His Majesty's Government may deem expedient. For the British Empire and allied countries, priority in connection with the supply of raw materials should be absolutely ensured, and to this end some organisation on the lines of the Commission Internationale Revitaillement for dealing with the orders of the allied Governments for reconstruction purposes should be established. At the same time the restrictive measures due to the control of home and foreign trade imposed during the war should be kept within

the narrowest possible limits, and wherever practicable the trades concerned should be entrusted with the working of the control under Government authority. Although it would not be practicable, or economically sound, in the view of the committee, to make the empire self-supporting in respect of all materials, a selective policy is recommended, which should have regard to the relative importance, whether industrial or military, and to the sources of supply and the likelihood of their disturbance in time of war, the object being that the Empire may be kept in a state of independence in respect of the supply of every essential commodity of any single foreign or possible combination of foreign countries. The committee, in connection with the supply of material, do not go so far as to prohibit alien interests in the sources of supply within the Empire, but consider that there should be some Government control. There should be complete disclosure, so far as is practicable, of the extent of foreign holdings in any particular case; mineral and other properties should not be secured by foreign concerns in order to prevent the development of those properties, and to check competition in supply; and, in the case of commodities of great imperial importance, the local government concerned should have some measure of control over the working of the properties. On the subject of essential industries, the committee repeat what they recommended in their interim report, favouring the establishment of a Special Industries Board, charged with the duty of watching the course of industrial development and of framing from time to time, when necessary, either on its own initiative or on the application of interested departments or persons, detail schemes for the promotion and assistance of the industries concerned with the production of commodities of a special character.

In view of what has been said regarding the difficulty experienced in all trades in connection with bulk manufacture, Lord Balfour of Burleigh's Committee take the strong view that consolidation and combination in respect of production and distribution are desirable in connection with the industry and commerce of the United Kingdom—notably, in securing supplies of material, in production (in which are included standardisation and scientific industrial research) and in marketing. There should be associations to serve as clearing houses of information of common interest, competent to advise on the needs in their respective trades as a whole. An authority should be set up which should have the right, after inquiry, to grant compulsory powers for the acquisition of land for industrial purposes, and the diversion or abolition of roads or footpaths. There should be a judicial body with compulsory powers to deal with the question of wayleaves required for the development of mineral royalties in the economical working of collieries. The committee recommend that the promotion of organisations for marketing in respect of oversea trade might stimulate the creation of combinations for the control of domestic sales. They believe that such development is not only desirable in some cases but practically inevitable under modern conditions, and that the attitude of public opinion, of local authorities and the State, which has hitherto been antagonistic, must be modified. They "consider, moreover, that, so far from being adverse to the interests of labour, combinations of employers are on the whole beneficial to the workers in the trade affected in respect of rates of wages, steadiness of employment and other matters." Such combinations should, where necessary, be legalised, so as to be enforceable between members. Combinations, where they involve agreement with foreign concerns, should be registered with the Board of Trade, with all information regarding the combination agreement, but where the combination is exclusively British such registration should only be optional. The Board of Trade, however, would have power to call for information regarding the operations of any combinations. By this means there would be eliminated any possibility of undue inflation of prices by such combinations.

The subject of finance and fiscal policy necessarily occupies an important part in the report of Lord Balfour's Committee. We are glad to note that, in regard to finance, opinion is not in favour of State-controlled institutions, as private banking enterprise is regarded as more elastic and effective, while the financial needs of industry are more likely, in normal circumstances, to receive examination and assistance. The existing control of capital should be relaxed as rapidly as circumstances permit after the war. Perhaps the most important view expressed, and one which can afford to be very considerably elaborated, is the opinion that the remedy for the shortage of capital after the war must be sought mainly in increase of production and saving. The attainment of these objects can be appreciably affected by the avoidance of unnecessary and wasteful expenditure by the State itself and by the extension of the taxation of luxuries. On the financial question, too, the committee attach importance to the inadequacy of the allowances now made for depreciation and wear and tear of machinery and plant. Depreciation should be allowed, for income-tax purposes, on a much more adequate scale than is at present the case. Indeed, the committee recommend careful consideration of the far-reaching effect of income-tax, at its present high level, on industrial reconstruction. The fiscal problem was one on which, perhaps more than any other, there was difference of opinion. Practically all of the committee favoured support, by import duties, of pivotal industries, the support of new industries and the prevention of dumping. But general custom duties or Government assistance in every form, they contended, should be afforded only to carefully selected branches of industry, which must be maintained, either for reasons of national safety or on general grounds, and that it was undesirable that any industry of real importance to our economic strength and well being should be allowed to be weakened by foreign competition or brought, to any serious extent, under alien domination or control. Overseas dominions and possessions are to have imperial preference. Treaties with allies and neutrals should be of such a nature as to render possible the utilising of such treaties for purposes of negotiation with them. Where an industry is healthy and vigorous, there is not the same need for protection or Government support. The committee, therefore, in their main report, recommend that a strong and competent board, with an independent status, should be established, to examine into all applications from industries for State assistance, to advise His Majesty's Government on such applications, and where a case is made out, to frame proposals as to the process and the nature and extent of the assistance to be given. Before recommending tariff protection such a board should consider forms of State assistance other than or concurrent with protective duties, and they should have constantly in mind the safeguarding of the interests of consumers and of labour, and make recommendations as to the conditions to be imposed for other purposes.

It should be said that the committees which investigated into the following industries emphasised the necessity for a tariff:—the iron and steel, engineering, electrical, carpet, woollen, linen, lace and embroidery, cotton, hosiery, fabric, glove, and non-ferrous metals. Those opposed to the tariff are the cotton, jute and shipbuilding industries.

The concluding part of the report deals with the subject of weights and measures and of coinage. Lord Balfour's Committee were unable to recommend the compulsory adoption of the metric system, as they were not satisfied that, on the whole, it was theoretically superior to our present system. As regards coinage, they look with some degree of sympathy on the decimalisation of the sovereign, which would be constituted of 1,000 mils, the mil being 4 per cent. less than the existing farthing; in other words, instead of 960 farthings there would be 1,000 mils in the £. They think, however, that this would not promote the unification of the existing coinage system of the Empire or the adoption of an international currency, although it would offer considerable convenience in accounting.

THE IMPOSSIBLE MAN.

The word "impossible," in the famous dictum of Napoleon, was only to be found in the dictionary of fools, but, to repeat a trite observation, even Napoleon found some things impracticable, if not sheer impossibilities.

One of the broad distinctions between the big man and the small is that the former is less ready to accept anything as impossible. It is, however, recognised as an attribute of the practical mind that it senses impossibility very quickly. While the idealist and the visionary will persist in vain beating of the air, the practical mind considers only practical expedients. Limitation in the sense of practical impossibility has had interest for mankind from the earliest times, for more than one classic legend concerns itself with the record of superhuman or impossible tasks.

In summing up men—and a knowledge of human characteristics and foibles is a necessary equipment to the engineer—certain individuals are dismissed from review as impossible. There are impossible men as well as impossible schemes, though both terms are after all relative. Impossible men are, as a rule, human misfits, traditional round men in square holes. The worst case is, however, best expressed by a biological term—arrested development—and such individuals are among the most distressing problems that either superior or inferior have to solve. Beaurocracy teems with impossible people, detached from the world of affairs, achieving position by seniority apart from capacity, ability being less important than the non-infringement of regulation. The individual who cannot act save by precedent; whose official mind commonsense is unable to disturb; whose superiority is assumed in his own estimation; who cannot see wood for trees or realise the world which moves adjacent to his own doorstep, it is from this type that deliverance is sorely needed.

It is an axiom whose truth cannot be controverted that all men are useful in some connection; there is one sphere of effort for which they are peculiarly suitable, the main trouble is that few there be who seem to find it. Unless the proposition be accepted, faith in one's fellow man is a sheer impossibility. The trouble about the field of effort is that some men in responsible positions should be breaking stones, they hamper progress and interfere with natural expansion. As cogs in the wheel of mechanism or spokes in the wheel of industry, they take the minimum amount of stress with the maximum of frictional resistance. Usually their self-satisfaction is so complete that neither sarcasm or veiled ridicule suffices to make them in the least uncomfortable, let alone to effect any reformation of their impossible disposition.

It is, of course, a mistaken notion that business acumen is hereditary, but the usual family ties which place son to follow father make this assumption, hence very often the presence of the impossible man in positions of real power. Only his staff know the bitterness of the position, and all sorts of stratagems are requisite to win a correct decision upon matters of vital importance.

The loss of industry due to paternal management is large, secure in possession of certain well-defined trade, there is no spirit of adventure which alone can create and expand. There are firms whose partners are too wealthy from the efforts of their forebears and who thereby have no spur to win achievement and good enough is let alone. From the national point of view the impossible man is a serious menace to trade supremacy. The case of arrested development is a particularly trying problem. A junior who, to all appearance, is worthy of promotion, is selected for advancement. He has been a dozen years with the concern, and an opportunity occurs of some importance. The selected man occupies the chair of office, and in spite of the stimulation of increased responsibility fails to respond. It would be cruelty to dismiss him; to retain him and break him is equally not to be thought of; a mistaken sense of kindness retains his services in the new capacity. Such a case is not unusual, it is indeed common enough to be familiar; further promotion is out of the question, but the fact remains that his retention and condonation foists an impossible

man upon his inferiors. His superiors having blundered, and failing to rectify their error need no sympathy, but his juniors are bound to suffer penalty by having to make good the deficiency and, in addition, to writhe under the conditions. Often enough to safeguard himself the impossible man surrounds himself in impenetrable mystery, he cannot give quick decision, he must hunt for external means to relieve his mind. When to impossibility is added a discourteous disposition—the two are coupled together often enough—the case is infinitely worse. A repellant exterior without that fine sensibility making contact readily and easily; added to vacuity of mind, are an almost intolerable mixture; such is often, however, the impossible man with limited power in his hands who affects the life of better men around him. Arrested development in the human species is a very curious problem, so extraordinary that one wonders wherein lies the mental disability when experience is unable to teach. Unlike material problems any solution or remedy is virtually impossible. Still many puzzling cases of insolvency and failure to expand on the part of old-established concerns are due to an overdose of impossible men.

The impossible man is the unreasonable man either through prejudice, want of commonsense, lack of experience, or inferior mentality. Men who are unconvinced, be the evidence never so plain, are always, in the eyes of their antagonist or adviser, impossible. Most men—certainly the great majority—are out of focus in one particular, on one subject or towards a particular range of ideas their attitude is unreasonable. Want of balance vitiates for the impossible man a whole realm of thought. Perhaps the difference between reason and unreason considered thus is the well-known difference between static and dynamic balance, it is when entrusted with responsibility that their impossible nature is made evident. In some individuals actions condemn opinions, no approximation is possible between their words and their deeds.

Eccentricity is pardonable or not if considered in relation to others; eccentricity if purely individual in character which does not affect ones neighbours is perhaps most easily ridiculed because most apparent and yet it may be the least impossible. To go further into this side of the subject would involve explaining the hinterland of lunacy.

To be impossible in some particular is the lot of most men, in one sense it makes humanity individual and interesting, without it a level of rational uniformity decidedly inhuman would be reached. What really matters is that out of the entire circumference of thought the impossible section should include only a few degrees. To rectify prejudice or impossible attitude and so minimise intolerance within a very small range is given by wide understanding and broad comprehension; a man who cultivates these can never be impossible. On the other hand the individual rightly considered impossible is one whose prejudiced sector of mentality leaves open only a few degrees of reason; in other words the greater part of his circumference is blind and his angle of vision severely restricted. To establish contact with this man is a puzzle, for usual tact and address do not placate, nor have ordinary methods of reasoning any validity to him.

Like the scheme rightly considered as impossible, the impossible man is uneconomic, for by the test of fitness and return he stands condemned. His chief feature is want of expansion, new ideas cannot penetrate and he makes no adjustment to environment, which is the one evidence of mental life. The failures of life are many but too often judged by externals the impossible man is a success, had he failed earlier he would not now occupy an altitude where his presence is a continual menace to other men's efficiency. He is the exception which perhaps proves the rule of the survival of the fittest, if he has any utility at all it is as a brake on the industrial machine. Events, methods, processes, might accelerate too quickly but for his presence and this perchance is why he remains an affliction to superior and subordinate alike.

Antique survivals have interest even in a progressive age, they interest the curious under glass in museums, but so far as industry is concerned they are obsolete and should be scrapped. The impossible man tends to render industry impossible; he has, by steady clinging to office caused many a prosperous concern to end its career; the usual trouble is that he does not realise his own impossibility, for if he did a miracle would be wrought—he would cease to be impossible.

THE IRON AND STEEL INSTITUTE.

THE forty-ninth annual general meeting of the Iron and Steel Institute was held yesterday and is being continued to-day at the hall of the Institution of Civil Engineers, Westminster. Sir William Beardmore, Bart., occupied the chair at the beginning of the proceedings.

THE REPORT OF THE COUNCIL.

The report of the council indicated that during the year 140 new members were elected; there were admitted also 57 associates, a new class of members, the formation of which was announced in the last report. The total membership of the Institute on December 31, 1917, was 1,994. The deepest sympathy of all members was extended to Mr. Eugene Schneider, president-elect, on account of the death of his son, Lieutenant Henri Paul Schneider, in action, on February 28, 1918; his aeroplane was shot down while attacking a greatly superior fleet of enemy aeroplanes. After landing, he was rescued, but died of his wounds a few hours later. Flight-Lieutenant L. P. Sidney was killed on October 2, 1917, during a flight over the German lines against a superior force.

The report then gave the names of a number of the members upon whom various honours and distinctions had been conferred during the year. It also stated that the accounts for the year showed that the total receipts of the Institute, excluding the income of the Carnegie Research Fund, were 5,427*l.*, and the ordinary expenditure 5,202*l.*, leaving a balance of 225*l.* The figures for the preceding year, 1916, were receipts 4,767*l.* and expenditure 4,208*l.*, and those for 1915 were 4,816*l.* and 4,275*l.* respectively, following 5,310*l.* and 4,701*l.* respectively in 1914. The reduction in the receipts in 1915 and 1916 was mainly due to the removal from the list of the names of members of enemy nationality, and it was gratifying to note that the effect of the measure upon the finances of the Institute had been only of a temporary nature.

GRANTS TO OTHER ASSOCIATIONS.

An Association for Research on Refractories was in process of formation. On the Organising Committee, of which Sir Richard T. Glazebrook was the chairman, the Institute had been represented by Sir William Beardmore, Bart., president; Sir Robert Hatfield, Bart.; and Mr. Cosmo Johns. A draft prospectus had been prepared, and when approved by the Department of Scientific and Industrial Research, would be issued to manufacturers and users of refractories, to universities and professional societies, and to certain trade unions, with an invitation to affiliate themselves with the association. The Iron and Steel Institute had contributed 25*l.* to the preliminary expenses of the Organising Committee. In answer to an appeal from the Engineering Standards Committee to join in raising a fund for the purposes of extending the scope of the committee's work in foreign countries, the council had voted the sum of 500*l.* as a contribution to the fund in question. The sum of 50*l.* was also voted last year to the Board of Scientific Societies to assist that body in carrying on its work.

COMMITTEE WORK.

During the year, meetings had been held by the several technical committees as follow: Committee No. 1, for Ores, Fuel, and Refractories, had met twice; Committee No. 2, for Blast-furnace Practice, three times; Committee No. 3, for Steel and its Mechanical Treatment, four times; Committee No. 4, for Iron and Steel Foundry Practice, twice; and Committee No. 5, for Metallography, Chemistry, and Physics, and its sub-committees, six times.

The work of Committee No. 1 had resulted in the production of two valuable papers, one on the "Properties of Refractory Materials," by Mr. Cosmo Johns, and one on the "Present Practice in Briquetting Iron Ore," by Messrs. G. Barrett and T. B. Rogerson. Committee No. 2 had conducted an inquiry into certain points connected with blast-furnace practice in this country, the results of which were embodied in a report to the present meeting. An inquiry into practice and economies in the use of blast-furnace gas was also made, and the information collected was being dealt with in a report by Mr. A. Lennox Leigh. The committee had also been instrumental in procuring other papers on blast-furnace practice which were on the programme now before the meeting. Committee No. 3 instituted an inquiry into certain points in connection with steel works practice, and presented two preliminary reports at the autumn meeting. The committee had in hand further work, which it was hoped would form the subject of a complete report at the next meeting. Committee No. 4 had co-operated with the Forging and Castings Department of the Ministry of Munitions on the subject of the manufacture of malleable castings, and presented to the department two reports, by Dr. W. H. Hatfield and Messrs. E. Adamson and J. E. Fletcher respectively, both of which were published in the last number of the Journal. The committee had also been inquiring into the present position with regard to steel foundry practice in this country. Committee No. 5 was working on the preparation of analytical steel standards, and on the invitation of the committee papers on other subjects within the scope of the committee had been brought forward by various members for discussion. The council's thanks were due to all the members of the committees for the work they have been able to accomplish, notwithstanding the pressing nature of their occupations at the present time.

EDUCATION OF ENGINEERS.

On October 25, 1917, a conference was held at the Institution of Civil Engineers to discuss the question of the education of engineers, at which Dr. Arthur Cooper was deputed by the council to attend. It was resolved to appoint a committee to initiate means for forming the central organization for improvement in, and better co-ordination of engineering training. Dr. Cooper was appointed to represent the Institute on that committee.

THE NEW PRESIDENT.

Sir William Beardmore then proceeded to induct into the chair his successor, Mr. Eugene Schneider, who had long been a member of council. He remarked that it was now his duty to demit office and to instal his successor. But before doing this he would like to thank the members again for the honour they had conferred upon him in electing him president, and to express his appreciation of the kind and willing co-operation of the Council and the staff in the performance of his duties during the two years of office.

To him it would always be a proud memory that, in those years of momentous events, coincidence placed him as president between a distinguished and valiant Belgian and a brilliant and patriotic Frenchman. As with our soldiers, French, Belgian, American, Portuguese, British, and many others, now fighting shoulder to shoulder before ancient Amiens and stricken Ypres, so the Institute's sequence of presidents was but a symbol of that unity of soul which animated the allies, and which was the greatest factor in our determination to triumph over the enemy of humanity. Iron and steel were most indispensable materials of war, whether as guns, projectiles, rifles or bayonets. We, as scientists or technicians, as employers of workmen, and employees, agreed to sink all questions before the one dominant duty of supplying our own men and our allies with plenty of munitions. To-day it would almost seem as if we had forgotten nationality in the greater claims of citizenship of a great commonwealth of humanity, and thus we were working with one accord, welcoming General Foch as Commander-in-Chief of the United Forces. We would not forget our duty as manufacturers to this great general and all his colleagues.

Just as M. Greiner was chosen for his professional qualities, so also was M. Schneider. It was a coincidence that he was also a most distinguished French metallurgist, parliamentarian and citizen.

We had watched with high admiration the development of the vast Schneider works. Curiously enough, they were partly run by British and French engineers, although not very successfully, before being taken over, in 1838, by the grandfather of the new president. He was a great ironmaster with great organising ability, and from the beginning of his connection with the works success was assured in ever-increasing volume. The ability, which justified his selection as a minister in the reign of Napoleon III and as president of the *Corps Législatif*, he found abundant scope for his great enterprise and initiative. Those qualities, too, passed to his son and to his grandson, and under the *régime* of the latter great advances had been made, not only in the volume of the work done, but in the quality. Sir William added that he needed only to mention casually their famous 75 mm. gun. There was one more link between the new president and this country. His mother was an English lady, and his wife was a direct descendant of James Stuart—James II of England. Thus the Institute welcomed him almost as a Briton; if not by birth, then certainly by devotion to our common cause.

It was not necessary in this Institute to say much of the untiring effort made by him in the development of the industries of France prior to the war. He had built up an immense business which had been of immeasurable service to France and her allies, and which had been continued during these years of war with a consummate skill and under great difficulties, due to an enormous proportion of the French supplies of raw material being cut off by the enemy's occupation of the ironfields. He had proved to be a great employer, with a noble desire to improve the condition of the workers. He had established his claim to be regarded as a great patriot, not only for his professional and philanthropic work, but for his loyalty, giving his best, even to the supreme sacrifice of his first-born. Thus the Institute welcomed him in this, the year of his majority as chief of his company, not only as a distinguished scientist, but as a devoted Frenchman and a highly appreciated ally.

The Bessemer Gold Medallist and the Presidential Address.

The first duty performed by the new president was to present Sir William Beardmore with the Bessemer gold medal for 1918, and he next proceeded to deliver his presidential address, which we reproduce in full on page 485 of the present issue. With these matters and the other proceedings at yesterday's meeting we shall deal next week.

(To be continued.)

NOTES.

Gas Traction.

The committee appointed last November by the Government to report on the subject of gas traction have issued an interim report which strongly supports the further development of the system. The report states that ordinary town gas can be safely, promptly and effectively substituted for petrol without reduction in the compression spaces in the engine cylinders. With gas of ordinary quality having a gross calorific value of 490 British thermal units to 500 British thermal units per cubic foot, a volume of 250 cub. ft may, it is stated, be taken as equivalent to 1 gallon of petrol. The relative cost, with gas at 4*s.* per thousand, thus corresponds to petrol at 1*s.* per gallon. The committee advise that no restrictions, save those arising from coal shortage or other war conditions, should be placed in the way of gas traction. The standard coupling for connecting up the gas receivers with the supply should, they recommend, be of iron, of 2¼-in. bore, screwed externally with the British standard pipe thread. The flexible containers should, the report states, be so mounted, in a tray at least 18 in. deep, that when the container collapses through the exhaustion of the gas there shall be no overhanging protuberances. The maximum height from wheel-tread to the top of the fully-extended receiver should not exceed 17 ft. Buildings in which vehicles fitted for gas traction are housed should be well ventilated. The committee report that the gas bags are sometimes made of such indifferent material that after a month's use as much gas is wasted by leakage as is effectively used. Where semi-rigid containers constructed of rubber or canvas are used the pressure should not exceed 90 lb. per square inch, and the internal diameter should not be greater than 4 in. Even so, they should, to be safe, be armoured with galvanised steel wire. Encouragement should, however, be given to the development of semi-rigid containers suitable for higher pressures.

The Secretary of State for the Air Forces.

Normally, we are not concerned with appointments to the Government, but Sir William Weir's selection as Secretary of State for the Royal Air Force is a matter of special congratulation to the whole engineering profession, as it is the first occasion when a working engineer has been chosen to be the head of a great State Department primarily concerned with engineering; and it will be a matter for further congratulation if, as is now certain, he is promoted to the high dignity of the peerage. Sir William, as is well known, is the eldest son of Mr. James Weir, one of the founders of the firm of Messrs. G. and J. Weir, Ltd., and himself an engineer of great inventive ingenuity and administrative capacity. Indeed, the excellence of the design of the firm's products, and the high degree of organised standard manufacture which characterised the early work of the founder of the firm, in association with the influences of heredity, have been important factors in the development of those qualities which have enabled Sir William Weir to advance so rapidly to the very responsible position with which His Majesty has now entrusted him. The works of the firm at Cathcart were, immediately on the declaration of war, utilised, first, for naval work, and, later, for the manufacture of aeroplanes and other munitions. The success achieved at once singled out Mr. Wm. Weir (as he then was) for important administrative work in the Government, and Mr. Lloyd George, then Minister of Munitions, utilised his great energy and quiet forcefulness as Director of Munitions for the whole of Scotland. Later, when it was realised that aeroplane manufacture was not organised as efficiently as the necessities of the air forces demanded, Mr. Weir became Controller of Aeronautical Supplies to the Army and Navy. Subsequently he became a member of the reconstituted Air Board, and in December of last year was appointed Director General of Aircraft Production, under the Ministry of Munitions, becoming in January of this year a member of the Air Council then established. About this time the dignity of knighthood was conferred upon him, and when Lord Rothermere retired from the newly-constituted office of Secretary of State for the Royal Air Forces there was general acceptance of the view that the man best suited for the position was Sir William Weir. In this we fully agree; and should he be able, as is certain, in view of his strong personal qualities, to override the inevitable stumbling blocks created by vested interests in all Government Departments, the country can confidently anticipate marked success, not only in respect to the design and production of aeroplanes, but in the utilisation of them to the fullest aggressive extent. This latter is the more probable, as it is known to those well informed that many of the uses to which aeroplanes have been put in recent military tactics originated in the fertile, imaginative brain of the new Air Minister.

Tribo- or Frictional Electricity.

The phenomena of frictional electricity, and particularly the fact that the charges which rubbed substances acquire are sometimes positive and sometimes negative, have not become much less obscure since the adoption of the term tribo-electricity. Recent investigators have paid increasing attention to the surface condition of the substances, however, which is certainly an important factor. But the phenomena remain puzzling. The tribo-electric series of Dr. P. E. Shaw, of Nottingham (Proceedings, Royal Society, November, 1917, pages 16 to 33), who investigated a large number of substances under different conditions, does not agree with other series. His abbreviated series is: Glass, wool, cat's fur, lead, silk, paper, cotton, wood, iron, ground glass, resin, copper, silver, sulphur. Any of these substances becomes electro-positive when rubbed with a material lower down in the series. But everything depends upon circumstances. To obtain equal conditions the different kinds of glass, including silica, were taken smooth and polished; the 20 metals and alloys tested were scraped, sand-papered or burnished to remove oxide, sulphate, &c.; the method of cleaning made no difference apparently. Twelve different woods, except ebony wood, gave practically the same values, whilst the 13 furs tried were distributed all over the series. Of two pieces of mica or celluloid from the same sheet one would turn positive, the other negative, when rubbed together. That a little surface dust or dirt proved of slight influence, one might explain by saying that repeated tests led to the production of equal conditions. But gentle pressure, brushing silk over quartz, *e.g.*, makes the silk positive, whilst hard rubbing makes it negative. Heating turned the specimens "abnormal" and changed their positions in the series. This was first observed in the case of glass which became negatively, instead of positively, electrified when hot. The critical temperatures were: For quartz, 300 deg. C.; for vulcanised fibre, 70 deg. C.; for most metals the critical temperature ranged from 130 deg. up to 240 deg. C. Pressing the specimens hot (with a flat iron, *e.g.*) and bending them also affected the charge and its size; the convex surface becoming positive to the concave. The behaviour of mercury was altogether peculiar. Most substances assumed a positive charge, when pushed gently into mercury, but acquired the opposite charge when plunged quickly into mercury; abnormal glass, polished or matt, was always negative to mercury, however, and so was abnormal mica. A glass rod, plunged into mercury, assumed a high charge, which decreased, however, on repeating the experiment several times; in hot mercury the charges of all the specimens were small. No theory seems to fit these observations. The metals are mixed up with insulators in the series. Yet Dr. Shaw thinks, the substances may be divided into two groups as to their behaviour when matt, abnormal, pressed or flexed. This grouping would be in contr diction to the largely prevailing idea that in the electric double layer at the surface of solids the negative charge is always outermost and most ready to escape. The phenomena rather seem to suggest that the surface layer generally differs from the solid underneath it, and that we know too little about these surface layers. Dr. Shaw found that polished glass was electrically neutral under certain conditions; gentle and hard friction might affect surface films in different ways. Dr. Shaw thought of experimenting in a vacuum to avoid or reduce gas action, but the mechanical difficulties of rubbing cleaned surfaces together in a vacuum would be great.

Trading with Enemy Act.—The Controller of the Foreign Trade Department has sent us a copy of a new list (No. 52) of additions to the Statutory List of firms of enemy nationality or enemy association with whom persons in the United Kingdom are forbidden to trade. Copies of this list can be obtained at a trifling cost from the Superintendent of Publications, H.M. Stationery Office, Imperial House, Kingsway, W.C.

The Keadby Railway and Highway Scherzer-Roller Lift Bridge.—Our readers will remember the complete series of drawings which we reproduced in Vol. civ, through the courtesy of Mr. J. B. Ball M.Inst.C.E., the engineer of this most interesting Scherzer roller-lift bridge, which spans the River Trent at Keadby, and is the largest Scherzer lift in this country. Since the articles were published we have had many requests to reprint them separately, so as to make the drawings more readily available for reference, and we have acceded to this request. The reprint, which can be had at the offices of Engineering, is priced at 7*s.* 6*d.*

Ammonia and Ammonia Products.—All purchasers of sulphate of ammonia for any purpose other than for use as a fertiliser, and all purchasers of anhydrous ammonia, liquid ammonia, salts or other preparations containing ammonia (except crude gas liquor) in monthly amounts greater than in the case of anhydrous ammonia, 56 lb. per month, and in the case of salts or other preparations containing ammonia 112 lb. per month, are recommended to register their names with the Director of Acid Supplies, Department of Explosives Supply, Storey's Gate, Westminster, S.W. 1, forwarding at the same time particulars of their consumption of each product referred to for the year 1917 and indicating the exact purpose for which the ammonia product is required.

IRON AND STEEL INSTITUTE.

Presidential Address.

By EUGÈNE SCHNEIDER.*

GENTLEMEN,—I should have scrupled to accept the presidency of the Iron and Steel Institute, aware as I am that my personal merit does not suffice to make me worthy of that very high honour, and that a far-distant residence renders it difficult for me to discharge the responsible duties of the office, had I not understood that, prompted by a sentiment for which I am deeply grateful, you wished, in selecting my person, to emphasise the absolute, hearty, loyal no less than thoughtful and resolute union, existing between Great Britain and France.

Your kindness has given voice to the thoughts that we share in common. United by mutual sacrifices, bereavements and hopes, we intend to remain undivided in victory. My hearty desire, as president of the Iron and Steel Institute is, with the cordial assistance and support of both my predecessors and my colleagues on the council, to draw still closer the economic bonds uniting our two countries; the unbroken development of such an alliance tending in the most efficient manner to disappoint our enemy in his insatiable lust of conquest.

Nor does it seem to me without profit, in order to prepare for the coming struggle, to seek even now in the tragic examples of the war for reasons and means of doing better than we have done hitherto.

Two years ago Sir William Beardmore told us, in his address, how the war had a long series of lessons to teach us, in the most varied provinces, ranging from ethics to politics and industry. In the last-named province, Sir William showed how scientific co-operation, that is to say co-operation between laboratory research and manufacturing development is one of the questions most emphatically thrust upon us by the events that we have been witnessing, and one demanding as prompt as possible an answer, in view of our industrial destinies after the war.

I believe that the greater number of the industrialists interested in the manufacture of steel, or any kind of manufacture in which the material used is steel or iron, on either side of the Channel, share Sir William's views. But the difficulty of the question certainly does not lie in the generalisation of these views; it seems to me, on the contrary, to reside in defining clearly the connection to be established between two groups of men who, up to now, have had few direct relations; the scientists on the one hand, and the industrialists on the other.

In the definition we are seeking for, difficult problems of organisation are involved; for a solution may be considered as satisfactory, only insomuch as it realises a complete harmonious balance between the different forces which we are using to obtain the sought-for results. Some are connected with the efforts of individual enterprise; others are the outcome of collective action, duly disciplined and, as it were, codified, and of the rational use of habits and traditions. We have no right to neglect that inheritance of the past. We should, on the contrary, in rearing our new fabric, avail ourselves, to the best of our ability, of any material at hand, provided it be serviceable.

We must first, in our opinion, make sure that our future organisation is so skilfully contrived as to provide individual enterprise with an open field broad enough or, as a mathematician would say, with a high enough degree of liberty. Industrial or scientific invention is, indeed, almost in every case, the product of a creative power in an individual endowed with active imagination. To quote an example, it is beyond doubt that we owe to the personal exertions of Henry Bessemer the manufacture of steel in a converter and also to those of Nasmyth (in England), and Bourdon (at Le Creusot), the invention of the steam-hammer.

However, science and industrial technique are both growing ever more complex. It is increasingly difficult, even for an exceptionally endowed mind, to store up, digest and finally use the mass of human knowledge contained to-day in one of the numerous branches that have sprung up on all sides out of the common stem formed by the discoveries of the scientists, engineers and industrialists of the later nineteenth century.

Our engineers, scientists and members of our industrial staff have less and less the possibility of getting at the knowledge of facts by direct observation and thus apprehending them in their reality; they must often needs accept ready-made doctrines and live in a world of theory. There lies the main danger, especially in a time such as the one we live in. The fate indeed of our industry depends on the right use of the "human material" we may have at our disposal, to the training of which we shall have to attend; and we must therefore solve, at the shortest notice, the most complex problems that have ever been set before man: I mean, we must discipline labour in both our countries, so that our different industries, at which war and the economic consequences of war have struck and will strike heavy blows, may recover their balance with the shortest possible delay; while we make sure in spite of that indispensable discipline and the extreme specialisation it involves, that we are recruiting powerful individualities whose exertions are necessary to progress.

In that respect, the iron industries form the basis of the gigantic fabric we are to rear; they are, so to speak, the gauge of industrial prosperity in a country, since, whenever industry expands, there is a demand for plant, and recourse is always had to metallurgy to develop plant. I may add that metallurgy is also the protecting shield that allows our two nations to resist the onslaught of German imperialism, and that it plays such an important part in the tremendous struggle, that few people realise it exactly, outside those who, like yourselves, are in familiar and everyday contact with the real facts.

Of course, almost everyone knows that the present war requires a far greater quantity of metal than any preceding one; but it seems to me that it may be interesting to enquire into certain of the more hidden causes of this new condition and into some of the consequences necessarily entailed, all the more so as this enquiry will provide us with concrete examples, calculated to expose the parts played on the one hand by scientific research and invention, and on the other by industrial organisation.

It is certain that the expenditure of ammunition exceeded, at the very outset, all anticipations founded on comparisons with previous campaigns. This circumstance appears to be due to stable, unbroken fronts, rendered possible by the huge number of men in the field. Military operations, under those conditions assume, with few exceptions, the character of a siege-war. The two enemies invest each other, and can effect no very ample movement unless part of the continuous rampart they are besieging or defending be previously broken through. As that rampart is not a mere line of walled defences, but is constituted in fact by an extensive area where is to be found a sporadical system of great depth formed by tier upon tier of varied works and guns of all sizes, one may well understand that, to neutralise a sector in view of an infantry attack, necessitates the expenditure of a greater number of shells than when the object, as formerly, was simply to demolish or fire a few houses in two or three villages. Instead of the 20,000 gun-shots with which Napoleon won the battle of Wagram, or the 1,500,000 shells that the Siege of Sebastopol cost the Allies, we must fire to-day several million shells to drive the enemy a few miles back on a very narrow front.

This, after all, is due to the fact that the accuracy of our gun-fire, and the high power of our explosives, are held in check by an adequate organisation of the shelters afforded to the infantry, the size of the targets being reduced to a minimum. It is interesting to compare the numbers of shells necessary to demolish, at average fighting range, a given length of one of those shelters, at different periods, for instance, in the Franco-German, Russo-Japanese, and in the present war.

The following table shows that the principal cause, apart from the difficulty of finding the range, of the present huge expenditure of shells is that the increasing accuracy of our guns has not been sufficient to counterbalance the diminished vulnerability of the objects aimed at.

DESTRUCTION OF AN INFANTRY SHELTER (ON A LENGTH OF 20 M., SAY 65 FT.).

Date	1870		1904		1916
Description of shelter	Park wall 2 m. (6 ft. 7 in.) in height)		Earthwork parapet		Narrow trench
Fighting range	1,500 m. (1,640 yds.)		1,500 m. (1,640 yds.)		3,000 m. (3,280 yds.)
Guns used, calibre	12 kg. (26.5 lb.)	4 kg. (8.8 lb.)	90 mm. (3 5/8 in.)	80 mm. (3 1/8 in.)	75 mm. (2 1/4 in.)
Probable vertical error	5 m. (16′ 5″)	6 m. 30 (20′ 9″)	1 m. 60 (5′ 6″)	2 m (6′ 7″)	1 m. 50 (5′ 11″)
Number of shots to take effect on target	28	84	80	110	40
Number of shots to fire after finding range	280	1,050	200	350	2,000
Weight of shells expended	3,360 kg. (3.30 tons)	4,200 kg. (4.12 tons)	1,600 kg. (1.57 tons)	1,900 kg. (1.86 tons)	11,500 kg. (11.30 tons)

Pieces of ordnance of 12 kg. and 4 kg. are of 1858 type (de la Hitte system).
Guns of 80 mm. and 90 mm. are of de Bange type; almost equivalent to the Arisaka material in use in Japanese Army.

The problem is of profound technical interest. But, before grasping the solution, how many varying factors must we take into account: the laws bearing on the combustion of gunpowder; the effect of priming; the transmitting of pressures in a gaseous mass in motion; the particular effects when the shell is near the muzzle; the effects of the flexibility of the gun and the gun-carriage; the varying resistances due to the varying directions given to the shell, &c.

The work may and must be done; but it will take up a considerable time, for how many erroneous theories will crop up in the minds of the enquirers before they hit upon the royal road leading to the desired result, that is to say, to the lessening of differences in muzzle velocity, angles of elevation, and disturbing motions in the projectile during its flight?

To a common-sense man it plainly appeared that to carry on such researches exclusively was out of season, and that we must provisionally admit, as a necessary fact, an expenditure of shells deemed until then impracticable, and find, in the use of improved methods of manufacture, the immediately indispensable resources.

Accordingly, I resolved to build new metallurgical plants at Le Creusot and Caen, with the view of producing a considerable tonnage of steel projectiles in the form of rolled bars, and of transforming directly all or part of the bars into nosed and heat-treated projectile blanks ranging from the 75 mm. calibre upwards (370, 400, 520 mm., or 15, 15·75, and 20·5 in. respectively).

No doubt such metallurgical plants, situated far from our mining districts of the North and of Lorraine, will suffer from certain industrial reactions when peace allows most of our ironworks in the East to begin work again. But I thought it permissible to neglect those future difficulties, in order to contribute to the defence of our allied countries to the utmost of my capacity. Moreover, I do not think it impossible that the metallurgical future of France will afford the means of procuring a satisfactory prosperity, not only to the ironworks working with the ores of Lorraine, but to such as receive their supplies from other districts of our country, provided, of course, that the manufactured products are adapted to local conditions of extraction, fuel, and motive-power respectively.

Together with other French friends, we proceeded to build powerful blast-furnaces, and steel works equipped with 60-ton open-hearth furnaces, and this effort has enabled us to provide our armies with the necessary projectiles, in spite of the enemy holding more than 70 per cent. of our iron and steel works.

A similar question is raised with regard to deterioration in the inner tubes of guns. The intense firing to which they are subjected more or less quickly corrodes the junction cone and the grooves of rifling, so that the accuracy and range decrease in a continuous manner, and a gun is useless after firing from 10,000 to 2,000 shots, according as it is a small or large calibre gun.

The engineers and ballisticians have naturally sought to reduce the effects of deterioration by a study of the very complex causes, the temperature of combustion of the powder, the maximum pressure, the calibre, &c. But it is evident that, knowing so little as we do about these things, the solution of the problem remains remote, and that, had we managed by laboratory experiments, to fix upon a quality of metal capable of withstanding the special erosion of guns, it was practically impossible to make the guns in course of manufacturing benefit by the discovery. We therefore took for granted deterioration, and consequently provided for the manufacture of spare tubes of guns.

Does this mean that we systematically avoided research? Quite the reverse, but we began by tackling problems admitting of an immediate solution, so to speak, and among the latter, above all such as tended to increase production. I am convinced that such a policy will have to be pursued still more strictly after the war.

So, with regard to metallurgy, we have built in France extremely powerful plants for the manufacture of cast-iron or open-hearth steel. The Caen blast-furnaces are to turn out, per unit, 450 tons per day, whereas, before the war, out of 123 such furnaces at work in France, but a few could turn out 250 tons. My new steel-works at Breuil, near Le Creusot, are equipped with 60-ton open-hearth furnaces, whereas the 30- to 35-ton type was already considered as very powerful.

Moreover, we are endeavouring to manufacture special high grade acid open-hearth steel for aeroplane motors and more generally for machinery intended to bear very high stresses and the results hitherto attained show that success is ahead. It is in that direction that our laboratories are working. It is not a question of merely finding some new metal, as the result of the skilful alloying of iron and rare metals, but on the contrary we are studying means for controlling the open-hearth process as securely as the mere melting in a crucible.

It would be tiring to review here all the questions we are now asked to solve. Perhaps, however, we may be allowed to select two more instances, in illustration of our idea of the part to be played by the engineers whose exceptional gifts help our technique to progress.

The greater part of the steel-ingots we are to produce will go to the rolling mill for conversion into billets or merchant bars.

Hitherto, the different operations in the rolling mill department, and in particular the drafting of grooves on the rolls, had been left to the care of men of experience, no doubt, but who were guided by empirical notions based a little on tradition and much on sentiment. The manufacture of projectiles showed us the benefit to be obtained by a thorough and, I may say, scientific study of the problem of hot-drawing of blanks or slabs. It is enough to say, for instance, that, with a properly selected speed of rolling, section of dies, piercing punches, drawing rings and punches, we are able to draw in one heating the largest projectile (520 mm. (20 15/32 in.) Schneider mortar) and to use in the process half as much power as was formerly deemed necessary.

To realise such a reduction of power in the rolling-mill department is, from an economic point of view, extremely interesting, but it is necessary to study methodically all the phenomena taking place during the various stages of rolling at the cogging mill and finishing mill. We must acknowledge that engineers in certain countries, had, if not anticipated us (for research had begun at Le Creusot as early as 1899) at any rate got ahead of us; the work of some of them is certainly calculated to give a sound basis to a really practical study; but it is necessary, if we wish the rolling-mill department to profit by it, for younger engineers, having the requisite scientific equipment and eager to solve an interesting industrial problem, to attack it without delay.

They have a starting point: the empirical rules of those that preceded them. These must absolutely be taken into account. They have at their disposal the means of measurement furnished by the electric motors of our mills and all our laboratory apparatus,

* Delivered Thursday, May 2.

pyrometers, extensometers, &c.; they must needs reach the goal.

When we represent, on a diagram, as functions of the number of passes, the values of the sections of the rolled product and of its chief sizes, we are often surprised that the points thus obtained do not form conti nuus curves, when we know very well that, special steel being excepted, the tenacity of carbon steel varies in a continuous manner as a function of the temperature. The simple readjustment of the curves thus obtained often conduces to a decrease in the number of passes, and to a better distribution of the power. It is obvious that the profit to be reaped from the study will be immediately felt.

I should like to say a word about another problem of an industrial type destined to be solved by our most skilled engineers. It is that of heating: heating industrial furnaces, heating boilers. It is an extraordinary fact that the art of making a fire and turning it to a good use is still in its infancy and that our heating apparatus are often very crude.

And yet we know the laws of combustion, gasification, radiation and convection. But it is probable that many builders of furnaces go on copying old models instead of investigating the working of their apparatus. How many times have we not heard that a cast of open-hearth steel had gone wrong because "the furnace was not properly heated."

I lay down as a principle that an open-hearth furnace should always work well. If the defect in heating is due to the choking-up of the regenerators, we must manage to get the dust to settle and allow, if necessary, the addition of heat over the top of the bath, with the aid, for instance, of oil-burners or any other process, such as the use of a cleaner of some artificial draught; for how can we admit that we cannot provide against an inconvenience which has been removed elsewhere?

If the defect in heating is due to the exceptional poverty of the gas, we must dispose of the means to better it, and these are numerous. In short, a systematic study of steel-furnaces will certainly lead to the remedying of many weaknesses in design and construction so that we may control their working and be as sure of their temperature as a stoker is sure of the pressure of his boiler.

The metallurgical works of the future must no longer afford the picturesque but regrettable sight, still too frequent to-day, of a crowd of chimneys all emitting an abundance of black or white smoke. The latter is steam. Perhaps apart from locomotives, no engine should emit steam in the open; the recovery of the calories contained in waste steam expanded to atmospheric pressure, and at a temperature of not more than 30° C., yields a power at least equal to that produced by the prime mover itself. This we have determined experimentally on the exhaust turbines driven by the steam winding machines in use in some of our collieries. Even the steam of our hammers can be utilised whenever there is a workshop with a large number of moderately-powerful engines.

The black smoke is the result of badly-constructed furnaces, or of insufficient discipline in the personnel of stokers. The latter may be remedied in a simple automatic way by the institution of a bounty system calculated according to the number of charges, as shown in the deprimometer. As to the building of furnaces, great improvements might be effected by the systematic application of a few well-known results of industrial physics. We may perceive, here, under one of its characteristic aspects, the question of "industrial output" as opposed to "mechanical output." In the greater number of cases, it is possible to represent by a figure the useful effect of some isolated engine or thermic apparatus; but the useful effect of a metallurgical plant is a function of a far greater number of variables, including at the same time measurable quantities of the physical order and "imponderables," such as the technical value of the personnel and their moral qualities.

The time is at hand when our works must yield their maximum useful effect, and, therefore, we should give all our attention to any loss, even those which formerly appeared negligible on account of their comparative smallness. Multiplied by the enormous tonnage of our future production, they will form a considerable total. For instance, the mere recovery of waste oil in a vast metallurgical works may give rise to a not inconsiderable profit.

But those are the minor aspects, one might say, of the question. More exactly, the problem of the industrial output may be studied from different points of view, the first of which is certainly a right use of the sources of heat and energy at the disposal of each country. That is a veritable State affair, concerning the whole community. In particular, with regard to ourselves, France does not dispose of a stock of mineral fuel corresponding to her wealth of iron ore. In 1913, whereas 23,000,000 tons of ore were extracted, her native coal mines provided only 4,000,000 tons of metallurgical coke, which, together with 3,000,000 tons imported coke, made up merely the 7,000,000 tons necessary to her production in cast iron (5,000,000 tons).

It behoves us, therefore, to cast up the account of our resources in hydraulic power, so as to reserve for metallurgical purposes the greatest possible part of our coal production. Those resources may even now be easily appropriated for the traction of trains and tram cars, lighting purposes, and the distribution of driving force over extensive zones, since a 60,000 voltage is in use, and one of 120,000 will be so very soon. Whereas the water-falls now utilised yield only from 700,000 h.p. to 800,000 h.p., future plans should allow a yield, at low water, of a minimum of 4,500,000 h.p. And as 1,000 hydraulic h.p. economise per year 10,000 tons of coal, in round numbers, the profit to expect from those plants will rise to 30,000,000 tons, that is to say, a figure approximating our total coal extraction before the war.

Metallurgical and mining industries are interested in this question not only indirectly in the way we have pointed out, but also directly, by the use of hydro-electric current to drive machines and even to produce metal.

The engineer's task, as we conceive it, begins here in an endeavour to combine harmoniously the use of thermic power as produced by the blast-furnace and coke-ovens, and hydro-electric power: the latter having the defect of being transmitted by very long lines exposed to many risks. It will, therefore, be well to provide very powerful thermic generating sets, ready for running at a moment's notice, capable of carrying on the work in the chief departments, pending the time when the thermic emergency stations have brought up to a maximum figure their normal reduced power.

That part will devolve upon groups worked by Diesel motors of 2,000 h.p., 4,000 h.p. and even 6,000 h.p., the price of oil-fuel being, in that case, a negligible matter. We are studying in France such motors and their realisation seems assured.

Hydraulic power will, in certain cases, be directly utilised in our metallurgical works, without previous electric transformation. Workshops turning out projectiles have already been equipped with hydraulic presses worked directly by water forced at high pressure through pipes. More powerful presses may be worked in a similar manner, and even rolling mills might be driven by high-pressure hydraulic turbines, transmitting their energy, in the case of reversible mill engines, through the medium of a Föttinger transformer. May I recall here that a similar installation was realised by us several years ago at the Terni steelworks for the manufacture of armour-plates (the power-transformer being electric).

The electric blast-furnace is not yet widely used in industry, but the development of electric furnaces destined to the production and refining of steel is certainly assured, especially in works using hydro-electric current as motive-power. It is likely that various combinations of the electric furnace with the Thomas converter or the basic open-hearth steel will, in future, be the characteristic feature of that special iron metallurgy which is the necessary consequence of a dual source of heat. It will be the topography of the region, or more exactly the place of the works on the "electric map" of France, that will determine the proportionate demand to be made from either of the two sources.

Those are entirely new vistas opening up before our engineers. Nor should they, on that account, forget the questions of internal organisation, more immediate and more varied in their form.

The immediate improvements capable of realisation in a great number of ironworks must strike the unbiassed visitor. It is seldom, indeed, that there is a perfect equipoise between the productiveness of furnaces and the output of forging machinery, presses, or hammers. Still more seldom has the general topography of the workshop been attended to and the position of the various engines planned with a view of ensuring a rational transit of the products through the different stages of their manufacture. The result of that general defect of organisation is always an increase of what is conventionally termed "dead stops," which ought more rightly to be called "harmful stops," for the power of words is great. The mere change of words might perhaps wake every mind to the necessity of reacting against such deplorable losses of time, which it is easy to reduce without any new inventions, but by instituting a better discipline. I carried out the following experiment, destined to show the importance of "dead stops" in current forging operations.

Two compressed steel ingots, weighing respectively 21 tons, were selected, as they came from the moulds, to be forged into three 220 mm. Schneider mortars (8·6 in.) and one 155 mm. Schneider howitzer (6 in.).

Particular attention was bestowed on the former through all forging operations; the latter was left to the current routine of the gunshop. Now, whereas it took 11½ days and seven heatings (plus one of annealing) to transform the former; for the latter 43 days and nine successive heatings (plus one of annealing) were necessary. The expenditure in fuel was, therefore, more considerable for the latter; but especially there was ample scope for "dead stops."

Thus in dealing with most industrial problems we are brought back to an examination of what will constitute a good organisation even before making research in scientific improvement. Such research must be undertaken only when once "our house is in order"—that is to say, when the adopted organisation sets each thing in its place and leaves the responsible heads with sufficient freedom of mind to devote a part of their time to technical questions. Lastly, the scientific research destined to improve the industrial technique is, it seems to me, of a rather special order, and, at any rate, notably different from research such as is practised by the scientists and professors of our great scientific institutions.

Some say pure science is disinterested, or, in other words, indifferent to results; that its goal is the truth, the pure, simple, naked truth, and that it is pursued for the pleasure of the pursuit; like a sportsman who enjoys the pleasure of a day's shooting but who is indifferent to the game he bags.

That is perhaps exaggerated. At any rate, the aims of the metallurgist are more practical; he too aims at scientific truth, but a truth which can be applied to some useful end; he is not like the pure scientist, all indifferent to the game he bags. I am convinced, also, that in no other branch of industry can the union of empirical knowledge and scientific research be attended with better results than in that of metallurgy.

The opinion is no doubt sanguine. For my part, I am inclined to think—and I believe I have shown you on what facts my opinion is grounded—that our metallurgical industrialists can derive much profit from scientific research, on condition that the questions are stated and treated in the proper manner—that is to say, in taking into account the results already attained, regardless of their origin, however empirical it may be, and, above all, in limiting the field of research to the immediately realisable object in view.

It was certainly to suggestions such as those that I have just outlined that the foundation of the National Physical Laboratory was due, and we cannot help wishing that this magnificent institution may completely fulfil the purpose that seems to be at the basis of all general progress in contemporary industry, and, above all, in metallurgy—namely, to establish and maintain a harmonious balance between the efforts devoted to disinterested general scientific research on the one hand and those spent in the pursuit of immediately utilisable results in the vast and varied provinces of technology.

It is certain that this balance is a function of the particular genius of each nation, and that, even if an organisation similar to the National Physical Laboratory was founded in my country, the part played by that institution in our industrial and technical development would be quite different from that which it plays in Great Britain.

Whereas, indeed, our French engineers and scientists are still imbued with the classical bias obtaining of old among us, and always seek to realise their scientific ideal by setting up doctrines of unexceptionable symmetry in accordance with the strictest rules of Cartesian logic, the British engineers and scientists, having outgrown that too rigid and geometrical discipline, more often obey the call of their independent imagination. The results thus attained constitute a vast province extremely varied in aspect, but it is plain that it is more than ever indispensable to sacrifice a little of the picturesque, and to set bounds to that splendid riot of individual enterprise, not with the view of marshalling individual minds in due order according to the German methods of work, and then stripping them of all spontaneity, but only to realise a unity of purpose necessary to their right use and quite consistent with the free play of each mind.

With regard to us French people, we must guard, not so much against the excesses of our scientific imagination, as against our exaggerated love of generalisation and of what we call "pure science," to which we are always tempted to give up the seat of honour even at the cost of neglecting a little too much technological researches which are, after all, those alone whose results are of immediate benefit.

I am afraid that I shall appear most exacting to our younger engineers, fresh from college, and fired with enthusiasm for the "scientific sport" that they have practised for many terms, and even more so no doubt to older scientists inured to disinterested research. But I am convinced that I am in the right, and I should be most happy to bring some of you to share my opinion, for a close collaboration of scientists and metallurgists on both sides of the Channel is certainly one of the chief factors in the rapid restoration of the balance of the world so gravely disturbed during the last years by the folly of German Imperialism.

NEW SHIPYARD AT CHRISTIANIA.—There seems no cessation in the projection or erection of new shipyards on the continent. A new Norwegian yard has been decided upon, the Standard Shipbuilding Company, with a capital of 3,000,000 kroner.

TIN ORDER, 1918.—An Order of the Minister of Munitions dated April 26, provides that no person except under licence may trade or deal in tin situate in the United Kingdom; or in tin situate outside the United Kingdom (except to carry out a written contract for tin existing prior to the Order); nor may tin be used without a licence in manufacture except for an order that comes within Class "A" in the Order as to priority of March 8, 1917. Certain monthly returns, beginning in May next, relating to stocks, sales, deliveries and orders are to be made, except by persons whose total stock in hand or on order has not exceeded 5 cwt. during the preceding months. "Tin" means tin of all qualities and includes sheet and rolled tin, tinfoil, scrap tin, tin ores and concentrates, and tin residues. Applications for licences should be made to the Director of Tin Supplies, Metal Exchange Buildings, Whittington-avenue, London, E.C. 3, and marked "Tin Licences." The amount and quality required per month and the use to which the tin will be put, must be stated.

THE LATE SIR SAMUEL BAGSTER BOULTON, BART.—We regret to have to record the death, which occurred on April 27, in his eighty-eighth year, of Sir Samuel Bagster Boulton, Bart., J.P., D.L., Knight of the Order of St. John of Jerusalem, F.R.G.S., Assoc.Inst.C.E., and Lord of the Manor of Totteridge. Sir Samuel was one of the joint founders of the well-known firm of Burt, Boulton and Haywood, Limited, timber merchants and contractors, of which he was the chairman at the time of his decease. He was also chairman of other companies and took an active part in promoting scientific methods in chemical and other industries. He became an Associate of the Institution of Civil Engineers in December, 1856, and received that Institution's Telford medal and premium. Sir Samuel was chairman of the London Labour Conciliation and Arbitration Board from 1889 to 1913, and he presided at the settlement of over 50 labour disputes. He was also a member of the Tariff Commission and, for a time, vice-president of the London Chamber of Commerce and president of the West Ham Chamber of Commerce.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—In the steel-making industry in the West of Scotland an intensified activity continues to mark the progress of events. Enormous quantities of material, both semi-finished and manufactured, are being turned out daily and deliveries are now very well in hand. The shipbuilding yards, the munition factories and the locomotive shops absorb the bulk of the output, and after they are supplied it has now been found possible to spare something for England. So far as export is concerned, a small portion of what might be termed the surplus output is being permitted to France and Italy for urgent Government needs—the construction and repair of railroads, &c. The requirements of ordinary mercantile consumers still receive but scant consideration, notwithstanding the great activity at the works.

Malleable Iron Trade.—Even with increased facilities for output, and that need attains to phenomenal dimensions, malleable ironmakers still find it difficult to meet the heavy demands made upon them and, despite every effort, supplies do lag behind. Marked bars are in constant request. Everything produced is being utilised for home purposes of national importance, and export has greatly decreased as a consequence of the difficulties attendant upon manufacturing.

Scotch Pig-Iron Trade.—Nothing quite new falls to be recorded of the pig-iron industry—the activity is excessive and the output quite in keeping, the demand for every grade, hematite for the steel works especially, continues strong, and practically no tonnage is available for other than purposes of the war. In order to give even a proportion of the material required to all and every home consumer whose needs are legitimately the needs of the nation, the stringent regulations and restrictions enacted by Government are rigidly enforced, and for all home business no alteration in price has taken place. Scarcity alike of material and of transport has caused a further dwindling away of export trade, with prices at an inverse ratio.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Vickers' Future.—It was evident from the speech of Mr. Douglas Vickers, presiding at the annual meeting of Messrs. Vickers, Limited, on Thursday last, that the directors have not been overlooking the question of future trade. Very definite plans have been decided on with regard to most of the firm's factories, but having in mind the character of productions which Messrs. Vickers, Limited, have been rapidly turning out since the latter end of 1914, there was probably nothing which struck one so forcibly in the course of Mr. Douglas Vickers' somewhat lengthy discourse as the announcement which he made that the firm intend to embark in an ambitious way upon the manufacture of sewing machines. This innovation, implying surely all the contrast between war and peace, seems to be awaited with an encouraging future. A machine has been evolved, and when tentatively placed on the market, proved an instantaneous success. So far as the firm's Sheffield works are concerned, what has been described as an ambitious programme has been drawn up. It mainly provides for the development of some of the older branches of trade which have been forced into a secondary position by growing armament demands.

Post-War Trade.—But the attention to post-war developments is not confined to Messrs. Vickers, Limited. Most firms have formulated schemes for trade after the war, and the extension of works has now been going on actively in many places for some time past. The latest man-power proposals are calculated to check progress in the operations, and it may be that in some instances the work will be definitely arrested.

Iron and Steel.—With perhaps the exception of the high-speed steel departments, the conditions in the trade this week are generally characterised by a greater degree of briskness. The supply of material for shells had been so satisfactory during February that even the demands created by the portentous happenings in France and Flanders during the past month have not called for an increased steel output for projectiles. As a consequence of the decline in the demands for shell steel, there has been a certain falling-off in the calls for high-speed material. The stocks left on hand are rather heavy, but in view of the exodus of men from the works, which has already commenced under the Man-Power Bill, these reserve supplies may prove helpful. The demand for aircraft and tank steel has not yet reached its limit, even though new plant has been put into use for the production of this class of material. A new 50-ton open-hearth furnace has been started at Templeborough, and at other places the producing capacity has been augmented. Shipbuilding steel production continues at a high pitch, and one hears of firms who have provided facilities for rapid production having been assured of several years work. Certain kinds of carbon crucible steel are in great demand. A scarcity of bar iron has manifested itself, and makers who are concentrating upon best bars find the expedient profitable. There is no appreciable improvement in the transport position. Wagons are still very scarce, and trade continues to be handicapped in consequence.

South Yorkshire Coal Trade.—In the coal trade supplies are markedly inadequate and the output is becoming smaller, due principally to the continued departure of men from the pits to the forces. Indeed, it is probable that the amount of fuel available has never been smaller since the outbreak of war than it is now. Preparations are in progress among merchants for the rationing scheme which is expected to be put into operation very soon. Best steam hards are in great demand, but there is very little offering on open market. Cobbles, nuts and slacks are scarce, a remark which also applies to household sorts. All qualities of coke are in request. Quotations:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* to 14*s.* 6*d.*; seconds, 13*s.* to 13*s.* 6*d.*; smalls, 9*s.* to 10*s.*, per ton at the pit.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—As was anticipated the liberal issue of May allocations of Cleveland pig-iron has stimulated business, and this week the market has been quite active, so far as home transactions are concerned. The report that the allocations to consumers in Scotland are to be on the priority system of classification is regarded with satisfaction. Hitherto consumers in England have been divided into classes according to the urgency of their needs, but in Scotland there has been no differentiation. Now, however, there are to be Class A and Class B allocations, and the former will be executed before any of the latter receive attention. Export trade is still on a very limited scale. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge all stand at 95*s.*, and No. 1 is 99*s.*; and for shipment to France and Italy, No. 3 and the lower qualities are 114*s.*, and No. 1 119*s.*

Hematite Iron.—Owing to the increased use of basic iron, and scrap for steel-making, the quantity of East-Coast hematite available is not only sufficient to meet all necessary home requirements but to leave a moderate surplus for despatch to customers abroad. Mixed Nos. are 122*s.* 6*d.* for home use and 147*s.* 6*d.* for export to France and Italy.

Manufactured Iron and Steel.—In the manufactured iron and steel industry pressure for delivery for Government purposes and for the shipyards is enormous. Prices, all round, are very stiff. The following are among the principal market quotations:—Common iron bars, 13*l.* 17*s.* 6*d.*; best bars, 14*l.* 5*s.*; double best bars, 14*l.* 12*s.* 6*d.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 17*s.* 6*d.*; steel bars (no test), 15*l.*; packing iron and steel (parallel), 13*l.* 10*s.*; packing iron and steel (tapered), 17*l.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.* Prices for export are not fixed, but they may be given approximately at from 40*s.* to 60*s.* per ton above home quotations.

Messrs. Dorman, Long and Co., Limited.—An extraordinary general meeting of the shareholders of Messrs. Dorman, Long and Co., Limited, is to be held at the Middlesbrough Offices of the firm on Tuesday next, to consider a resolution that the capital be increased to 3,000,000*l.* by the creation of 1,500,000 shares of 1*l.* each, to be known as preferred ordinary shares. The issue of new capital is necessary following upon the purchase of the shares of Messrs. Sir B. Samuelson and Co., Limited. The new shares will bear a non-cumulative dividend of 8 per cent. per annum, and will be offered to the existing shareholders.

Shipments of Iron and Steel.—For the month of April shipments of pig-iron from the port of Middlesbrough amounted to 35,851 tons, as compared with 25,950 tons for the previous month, and 37,297 tons for April last year; clearances of manufactured iron for the fourth month of the year were returned at 518 tons, as compared with 642 tons for the previous month, and 2,577 tons for April last year; and despatches of steel for the month just ended were given at 5,673 tons, as compared with 8,982 tons for the previous month, and 17,655 tons for April last year.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—Although the result of the conference between the coal factors interested in the south-western counties trade and the Controller of Coal Mines has not been officially disclosed, it is understood that under the scheme formulated it is intended that six factors in the south-western counties shall act as representatives of the 400 or 500 coal merchants ordinarily trading in those districts; that they should then pass on the orders for all destinations to another factor at Cardiff; and that the Cardiff factor shall deal exclusively with the collieries. By this arrangement it is intended that the collieries should deal with one instead of some hundreds of contractors, and that the supplies should be forwarded in large lots, and not as at present in small quantities in accordance with local requirements. Transport, it is contended, will thus be considerably economised, and colliery clerical work largely reduced. On the other hand, those who are not enamoured of the scheme contend that it involves an unnecessary and unfair interference with private interests, and representations to this effect are being made to the Coal Controller of Coal Mines, with what result remains to be seen. The new instructions scheduling ports of shipment have been better received than most similar instructions in 1916. Collieries are not allowed such freedom in the choice of ports as was the case in the previous Order, but a provision is made by which exemption may be obtained, and this is regarded as a practical feature of the scheme. The main reason for its introduction is that of giving the Great Western Railway a larger measure of relief with regard to coal traffic between Newport and Llanelly. The strength of the steam coal market is fully maintained this week. Bituminous coals are also in good demand, and there is evidence that the request to stock house coals has not been in vain. Small coals, too, are relatively scarce, while even through coals are far from showing any weakness. Pitwood supplies continue satisfactory, and with improved weather conditions an increased supply is anticipated from home sources.

Newport.—Favourable conditions continue to prevail in the market for Monmouthshire coals. These are still benefiting from the relative scarcity in the supply of the best steam coal descriptions, the output of which continues short of the demand. Rapid progress is being made with the calling-up of miners. It is even complained that the recruiting authorities are not in every case observing strictly the conditions in regard to notices. This drain necessarily checks any expansion in the production of coal which might otherwise take place and points in the direction of a comparatively prolonged shortage so long as the present favourable conditions obtain. The distribution of wagons is better than it was last week, and the causes which were then responsible for stoppage of work at certain pits have been removed.

The Allocation of Orders Scheme again Suspended.—The Coal and Coke Supplies Committee for South Wales and Monmouthshire this week decided to suspend for the time being the scheme inaugurated a few weeks ago for a restriction on outputs. Since the Easter holidays, contrary to the experience for some time previously, the collieries have not been able to keep pace with the demand. They have made every possible effort to increase output, but they have been handicapped by the increasing shortage in the supply of labour, and the demand has continued in excess of the supply. It was for these reasons that the Coal and Coke Supplies Committee deferred for a week the original date fixed for the allocation scheme, and it is because of the persistent pressure of the requirements of the authorities that it has now even further decided to withdraw the allocations for the month ending May 11, and to allow the collieries to produce up to the maximum of their capacity. The decision of the committee was communicated yesterday by Mr. Finlay A. Gibson (the secretary), to all the South Wales collieries in the terms of the following letter: "The committee at a meeting held to-day, had under consideration the question of increasing the permitted outputs of all the colliery companies in the coalfield in view of the altered position of the coal trade which has arisen owing to the increased tonnage which is now, and, it is anticipated, will be, available. The committee decided that the scheme must remain in force, but under the special circumstances already named, each colliery company will be permitted to produce the fullest possible output in the period which expires on May 11 next. In view of this arrangement each colliery company must, however, continue to supply all their customers with the full quantity of coal for home consumption to which the latter are entitled under contracts entered into, and all the colliery owners will be required, as hitherto, to carry out any allocations made by the committee of quantities for home consumption."

THE INSTITUTION OF CIVIL ENGINEERS.—At the annual general meeting of the Institution of Civil Engineers held on Tuesday, April 23, the result of the ballot for the election of officers for the year 1918–19 was declared as follows: President, Sir John A. F. Aspinall, M.Eng. (Liverpool); vice-presidents: Sir John P. Griffith, M.A.I. (Dublin); Mr. John A. Brodie, M.Eng. (Liverpool); Mr. W. B. Worthington, B.Sc. (Derby); Dr. W. H. Maw (London); other members of council: Dr. Charles G. Carpenter (London); Sir Dugald Clerk, K.B.E., D.Sc., F.R.S. (London); Colonel R. E. B. Crompton, C.B. (London); Mr. Maurice Deacon (Matlock); Sir Archibald Denny, Bart. (Dumbarton); Mr. G. H. Duggan (Canada); Sir William H. Ellis, G.B.E. (Sheffield); Sir Robert R. Gales (India); Mr. W. W. Grierson, C.B.E. (London); Sir Robert A. Hadfield, Bart., D.Sc., M.Met., F.R.S. (London); Brigadier-General Brodie H. Henderson, C.M.G. (London); Mr. R. W. Holmes (New Zealand); Mr. G. W. Humphreys (London); Mr. Summers Hunter, C.B.E. (Tynemouth); Mr. M. E. Kernot (Australia); Lieutenant-Colonel Charles L. Morgan, C.B.E. (London); Mr. Basil Mott (London); Engineer-Vice-Admiral Sir Henry J. Oram, K.C.B., F.R.S. (London); Mr. Frederick Palmer, C.I.E. (London); Mr. J. W. Restler (London); Captain H. Riall Sankey, C.B., R.E. (retired) (London); Sir John F. C. Snell (London); Mr. E. F. C. Trench, M.A., B.A.I. (London); Mr. T. R. J. Ward, C.I.E., M.V.O. (India); Mr. E. J. Way (South Africa); Sir Alfred F. Yarrow, Bart. (Hindhead). This council will take office on the first Tuesday in November, 1918. The council of the Institution of Civil Engineers have made the following awards for papers read and discussed during the session 1917–18: Telford gold medals to Sir Robert R. Gales, F.C.H. (India), and Mr. Edward Sandeman (London); George Stephenson gold medals to the Hon. Sir Francis J. E. Spring, K.C.I.E., and Mr. H. H. G. Mitchell (Madras); and Telford premiums to Mr. W. L. Lowe Brown, M.Sc. (London), Mr. G. Blake Walker (Barnsley), and Mr. Alwyne Meade (Blackheath). Indian premiums also have been awarded to Sir Robert Gales and Sir Francis Spring. The awards for papers published in the Proceedings without discussion will be announced later.

THE CANAL QUESTION.

To the Editor of Engineering.

Sir,—I will not attempt to reply to Mr. Perman's suggestion that punters object to commercial traffic on the Upper Thames until I meet a bargee who takes the slightest heed of such objections, and does not give better than he gets in the way of abuse. If the river carried all the traffic which it ought to do according to canal advocates, no heed would be taken by the authorities of the grumbling of mere pleasure seekers. No doubt the Thames Conservancy know where their interests lie and act accordingly.

Mr. Perman says that 100-ton barges can run to Reading and 60-ton barges to Oxford. He adds that if large-sized barges and deep-draught tugs could navigate right through to Oxford the volume of merchandise would be considerably increased. Quite so. This is what we always hear about canals. We are told that if the canals of the country could accommodate 60-ton barges in place of 25-ton boats this would force down the railway rates, and our manufacturers would be immensely benefited.

Now the Thames can accommodate 60-ton barges, and yet it effects but little, although the capital charges are small. Greater depth would involve increased charges and then there would be an outcry for free canals, such as are provided in France.

The Thames, as it is, affords as good a waterway as any in the country, and far better than most, and yet it carries very little traffic. If it were crowded with barges it would afford an excellent argument for the extension of canals. But it is not.

Yours truly,

May 1, 1918. "Punter."

ELECTRICITY *versus* GAS AND COAL FOR DOMESTIC USE.

To the Editor of Engineering.

Sir,—Your correspondent with the same initials as my own fires off a rather dogmatic statement on the above subject without any apparent direct stimulus from foregoing matter in your columns, so presumably it arises from the atmosphere created by the "Coal Conservation" report. As I happen lately to have been talking a good deal about these matters within my circles, and as I am admittedly a Philistine, I think your correspondent will, with your permission, be glad not to be identified with me.

I cannot at all agree with his second paragraph, and I venture to think that only electrical enthusiasts who are out to sell electrical stuff will either. In the first place, all coals are not suitable for coking, and in the second place, the coal bill is by no means the item that determines the price of electricity, as he might know casually by a consideration of hydro-electric supplies. Even at ½*d.* a unit (the Coal Commissioners' ideal) domestic electric heating is prohibitive to any but the wealthy. What is the use of a one unit stove, or even a two, in a room? And in the third place there is still that 60 per cent. to 70 per cent. of the heat going to waste into the condenser or atmosphere.

That is the problem to solve. By all means, coke and by-product to the utmost extent, but as I said last August, and as so many others are saying (would that there were more!), let us get electricity down to being a by-product itself at a by-product price before we talk too much about using electricity as a source of heat.

Yours faithfully,

Alexander A. Jude.

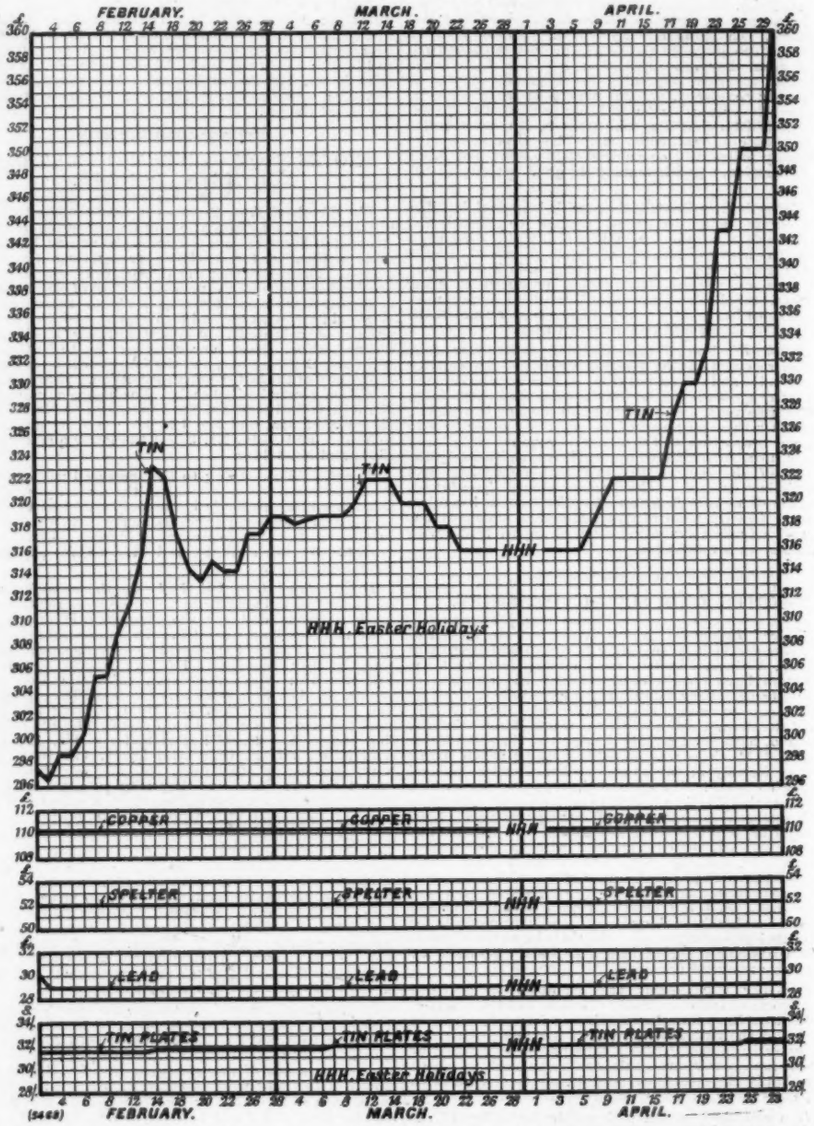
90, Trafalgar-road, Moseley, Birmingham,
April 30, 1918.

British Scientific Products Exhibition.—The British Science Guild is organising a comprehensive exhibition of products and appliances of scientific and industrial interest which prior to the war were obtained chiefly from enemy countries but are now produced in the United Kingdom. The exhibition will be held at King's College, London, for four weeks during the coming summer. It will probably come as a considerable surprise to the public to know how much has been accomplished here since the war, in industries in which previously we had been falling behind; and it is believed that the effect of the exhibition will be to have a most stimulating influence upon scientific and industrial research, by bringing home to manufacturers, as well as to the public, the supreme importance of science in industry. The organising secretary for the exhibition is Mr. F. S. Spiers, 82, Victoria-street, and particulars of the exhibition will be issued shortly.

Viscosity and Constitution of Lubricating Oils: Correction.—In our report on the paper on the "Relation between Viscosity and the Chemical Constitution of Lubricating Oils," which Dr. A. E. Dunstan and Dr. F. B. Thole read before the Institution of Petroleum Technologists on April 16, we stated, on page 433 of the issue of April 19 (in the first paragraph of the third column), that the oil particles were estimated to have a maximum diameter of 0·03 mm. We are indebted to Dr. Dunstan for pointing out to us that he had given this figure to indicate the size which large colloidal aggregates approached. "In the case of oil iso-colloids the aggregates are so small that ordinary illumination in the ultramicroscope fails to resolve them; and all that one sees is the Tyndall cone effect. Possibly with very intense lighting resolution could be effected. Note may perhaps be made of the very characteristic fluorescence that is so distinctive of each type of oil. For example, Persian oils exhibit a green and Burmah oil a brilliant blue in the field of view."

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



Note.—In the diagram above the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, as far as they have been reported, for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. The prices are per ton. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each. On July 7, 1916, the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig iron was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6*d.* per ton. These quotations are still in force. (For official regulations see page 45, vol. cii.)

Table of Temperatures.—We have received from the Cambridge Scientific Instrument Company, Limited, a copy of a chart which they have prepared for converting temperatures from Centigrade to Fahrenheit, or *vice versa*. This conversion chart is in the form of a spiral, and is printed in red and black on a varnished card measuring 12 in. by 14½ in., with a column of useful data on each side of the chart. Any temperature from − 460 F. to 3,630 F. and the equivalent Centigrade temperatures can be read at a glance. The table will be sent free by the company to anyone interested, on receipt of six penny stamps to cover postage.

Timber Order, 1918.—The Board of Trade direct attention to the terms of the Timber Order, 1918, published in *The London Gazette* for April 26. Under this Order, a permit is necessary from the Controller of Timber Supplies, Board of Trade, Caxton House, Tothill-street, Westminster, London, S.W. 1, before entering into any transaction relating to timber grown outside the United Kingdom and not actually in stock in the United Kingdom. A permit is also necessary before receiving or arranging for the transport of any such timber not in stock in the United Kingdom. Holders of licences to import are not excepted and must apply to the Controller of Timber Supplies before arranging for the charter of tonnage or taking delivery of timber purchased abroad. The Order will, it is expected, be followed before long by another, regulating not only dealing in timber, but also its use in this country, whether grown outside or inside the United Kingdom. Virtually the entire importation of timber will be effected on account of the Government, this arrangement following upon prolonged negotiations between the Controller of Timber Supplies and representatives of the timber trade. The Order is not designed to interfere with the normal business of firms established in the Dominions or Colonies as timber producers, but is intended to prevent speculative transactions in timber in the countries of origin by or on behalf of persons in the United Kingdom.

VERTICAL TESTING MACHINE WITH RECORDER.

CONSTRUCTED BY MESSRS. SAMUEL DENISON AND SON, LIMITED, LEEDS.

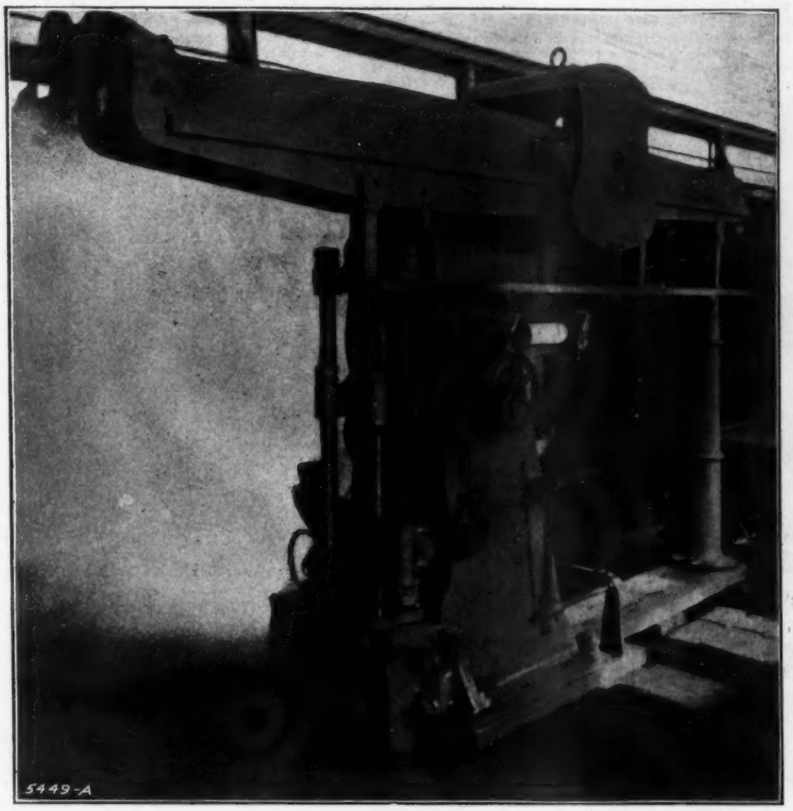


FIG. 1.

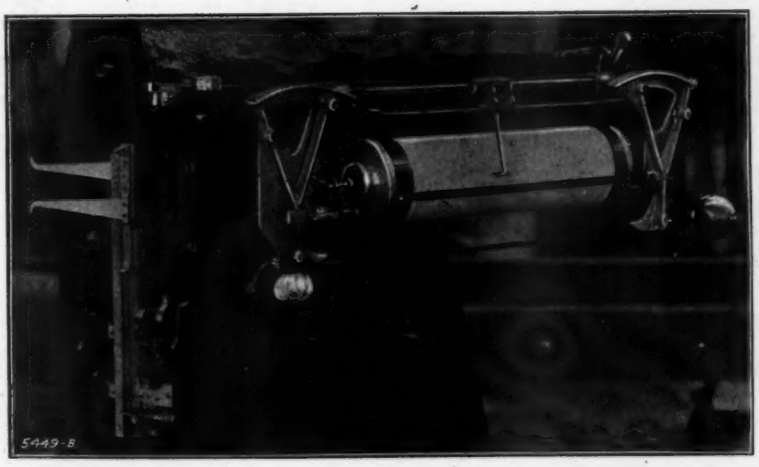


FIG. 2.

We illustrate in the views Figs. 1 and 2 herewith the Denison testing machine, which is built by Messrs. Samuel Denison and Son, Limited, Leeds. It is of the single-lever vertical type, and conforms to all the requirements of the Board of Trade, Admiralty and British Standard Departments, for testing materials in tension, compression, deflection and shear.

An indispensable feature of any testing machine is the ability instantly to vary the speed at which the load is applied, to suit the particular specimen under test, and also to effect this smoothly and without jerks as the test proceeds. In the Denison machine, this feature is secured by employing a patent hydraulic pump for producing the pressure in the straining cylinder. This pump has a variable delivery in either direction whilst being continuously driven in one direction only. It is adapted for being driven by a direct-coupled electric motor or by belt from a countershaft. The pump is started in neutral position, and the turning of a hand wheel decides in which direction and at what speed the straining head shall move. A similar pump is used for the propulsion of the jockey weight; the speed at which it travels in either direction being controlled by the movement of a conveniently placed lever.

The tests are all accessible from the front of the machine; an inspector can stand under the steelyard gear to review the test as it proceeds, the operator standing at the side, manipulating the machine and having the control wheel and lever within convenient reach. The machine has the beam, upon which deflection, compression and shear tests are made, permanently attached so that any test can be instantly undertaken without the equilibrium of the steelyard being disturbed.

The specimen in each class of test is equally accessible and is situated at a convenient height from the ground. Careful attention is given to the holders of the tensile specimens so as to ensure a true, straight-line pull. The grips can be readily changed in favour of another size, by merely drawing them forward, and, by a reverse process, others can easily be inserted, all being interchangeable. Headed, screwed or unprepared specimens can be tested, and in the case of the latter, the serrated grips are key-controlled to open and close in pairs, which is a distinct advance over the usual practice. All tensile specimens can be rapidly inserted between the grips from the front, which is also an advantage over the usual threading-up method. Telltale devices for indicating unmistakeably to the operator all the different functions of the machine, such as speed of stress, oscillations of the steelyard, &c., are provided, and all are concentrated together within easy focus of the operator's eye.

The loads at which the yield-point and elastic limit must be reached are frequently defined in specifications, and for this purpose it is necessary that a stress-strain diagram be obtained; such a diagram is more reliably and more quickly produced automatically. This function is a most difficult one to fulfil. Owing to the results of continual experiment and improvement, the patent autographic recorder on the Denison tester possesses essential features which make it easy to obtain a reliable diagram, features which will appeal to all users of the machine. The arrangement differs from others in that the operator can proceed with the test in the usual manner, the recorder automatically and simultaneously taking care of the diagram right up to the point of rupture. At the end of the test, the load carried by the specimen can be read from the steelyard in the usual way, and at the same time a permanent duplicated record is to hand, showing the behaviour of the specimen at every stage of the test. The recorder, being automatic, does not record upon the chart any erroneous fluctuations of the steelyard due to lack of equilibrium. The diagram must be magnified as much as possible, and to this end, the recorder can be adjusted to give any of several magnifications to suit the capacity of the specimen. Special provision is made to eliminate loss of motion due to friction in recording and magnifying the extension ordinate, so that friction is not increased with increased magnification. The pens are mounted upon a frictionless carriage producing a straight line horizontal movement.

THE EASTERN IRON TRADE OF THE ROMAN EMPIRE.—The belief, to which renewed expression has been given in recent books, that the Romans imported steel from China, seems to rest on one single statement in the "Historia Naturales" of Plinius. Reviewing the literature on the subject, Mr. Wilfred H. Schoff, of the Commercial Museum of Philadelphia, in a paper presented in December, 1915, to the American Oriental Society, now reprinted in pamphlet form under the above title, arrives at the conclusion that the Romans obtained most of their iron from their mines on the island of Elba, in Spain and in the Alps, and that their superior steel of which they made a limited use, came from Central India, the source of all good iron two thousand years ago and in more recent times, and not from China. The statement of Plinius is as follows:—"Of all kinds the palm is due to the Sêric iron. The Seres send this with their textile fabrics and skins. The second place is due to the Parthians, and there are no other kinds of iron which are tempered into the true steel, for they are mixed with other elements." The last sentence, which may be translated in different ways, runs in Latin: "Neque alia genera ferri ex mera acie temperantur, caeteris enim admiscentur." Schoff points out that there is a double confusion in Plinius; Seres was the Roman name for the Chinese, but the iron did not come from there, and it had nothing to do with the silk which certainly did come from Chinese Turkestan. The ancient Chinese manufactured iron utensils, pots, ploughs, but not superior steel, chiefly in the north-west of their country, or more likely in the north-east, in what is now called Shan-Tung; to transport that iron overland would have taken the caravans the best part of a year and could not possibly have paid; it was different with silk, which was worth its weight in gold in Rome, and was condemned as a luxury by Tiberius and other emperors. The Indian iron was shipped to Southern Arabia and the African Horn (Abyssinia, Berbera, &c.) by Tamils and Arabs, who had a monopoly in that trade; the Romans thought it came from there, like the cinnamon bark, and the name of this country, Chera, was changed into Seri by the Tamil, and confused with Seres. In North Africa, steel is still known as "hint" (al hinde). The pamphlet contains much interesting information about the Indian steel industry which was centred in Haidarabad, and which has been much discussed by those who have attempted to trace the history of the arts in early times.

NOTES ON A GAS-COKE-PRODUCER-FIRED GLASS TANK FURNACE FOR THE PRODUCTION OF WHITE GLASS.*

By MR. A. B. ROXBURGH.

THE fuel almost universally used in all forms of glass furnace is bituminous coal, that is coal which, when distilled, yields gas, coke and by-products such as sulphate of ammonia, and tar—from which last are prepared many things ranging from fuel oil and light hydrocarbons for use in motor vehicles to the thousand-and-one derivatives that crowd the chemist's laboratory and the apothecary's shelves. When, however, this bituminous coal is burned for heating purposes, either in direct-heated furnaces or through an ordinary producer, the only residue is ash, a substance which it generally costs a not inconsiderable figure to get rid of. There are purposes, of course, for which a non-bituminous fuel can be used—directly-fired—but this does not apply in glass manufacture, except to a small extent in the lehr, because a long flame is necessary to ensure the equal distribution of heat. A non-bituminous fuel in a direct-fired furnace would give far too local a heat and probably require too much draught, and so, following the line of least resistance, the best gas-producing coal that can be procured locally is generally used.

These were the lines of thought that I had in my mind when I first discussed with Mr. Ferry the suitability of gas-coke for glass furnaces. He kindly allowed me to inspect his furnaces, and I immediately saw that to fire with coke in a direct-heated furnace would be quite useless, and that the only way to effect the desired result would be, first to gasify the coke in a producer. I took steps to get this tried in a producer as ordinarily constructed, in which good steam or non-coking coal is used, but found that, owing to the unsuitability of the ordinary producer, trouble immediately ensued, and the experiments had to be abandoned. Concurrently, Mr. Ferry was experiencing considerable trouble in obtaining pots and also with their breaking, so that the question suggested itself whether the pots could be entirely dispensed with, and as this would entail direct contact between the gas and the metal, whether, provided a perfectly clean gas of constant quality could be obtained, this would have no deleterious effect on the metal. In order to prove this, a small experimental tank furnace was constructed, which was heated by ordinary town's gas. The gas was supplied at ordinary town's pressure and the air necessary for its combustion was supplied from a rotary compressor at 2 lb. per square inch pressure. The flame was caused to impinge directly on the metal and no resultant discolouration whatever of the glass was perceptible.

After much discussion it was then decided to construct an experimental tank furnace to be heated by a gas-coke-fired producer, special precautions being taken to ensure that no dust from the producer should be allowed to reach the glass; that the producer should be of the simplest possible construction, that the attention necessary should be the minimum, and that the whole should work under natural draught without the use of even a steam boiler. As the plans progressed, it was seen that the scheme might have very important results in the glass industry and many others, and so patents were sought and obtained for the means of vapourising the water, cleaning, &c., and for the removal of dust from the gas.

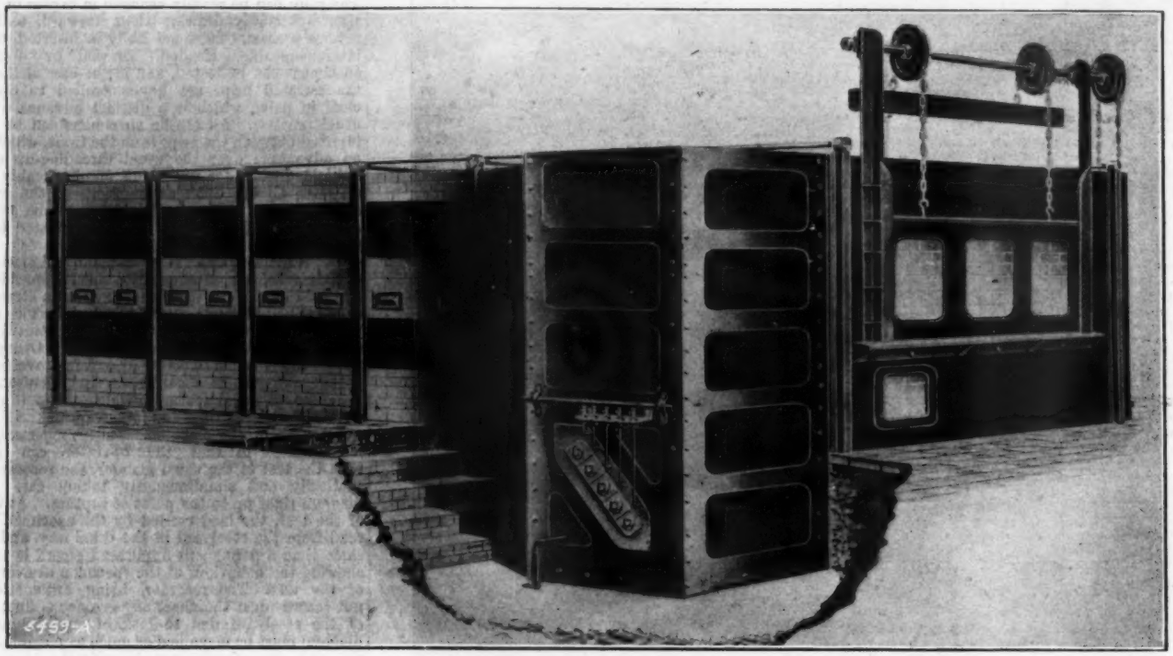


FIG. 1.

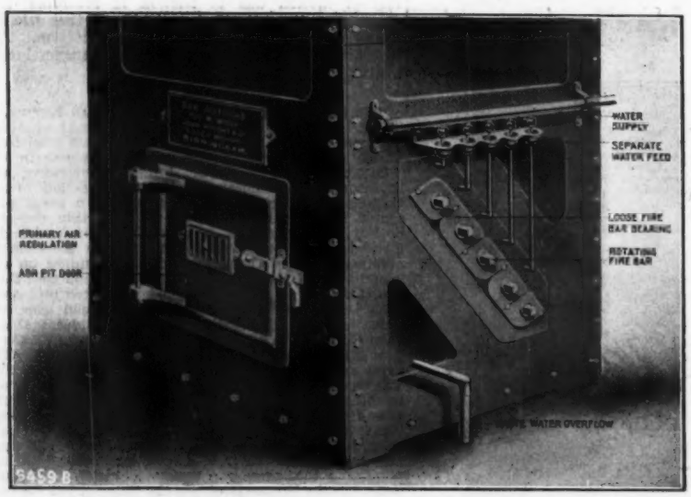
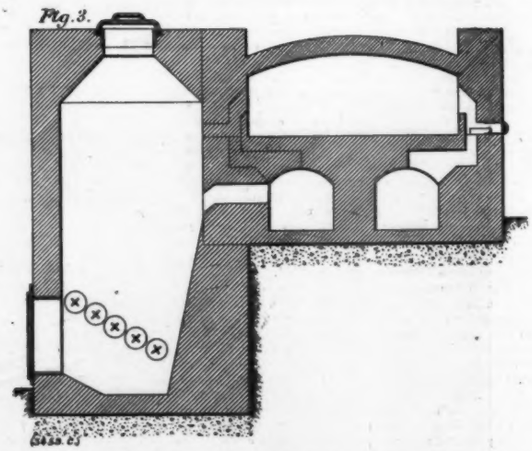


FIG. 2.

Fig. 3.



The special type of producer evolved will be clearly seen from the illustrations above. The bars (Fig. 3) are of cruciform section and placed horizontally, but in an inclined plane. The bars in the smaller size are of special construction, which has been found peculiarly effective. Whichever section of the cruciform bar is uppermost forms a water channel, and each bar can be rotated separately by means of its outward-projecting ends, and it will be observed that it is an extremely easy matter to remove ash and break up any clinker by simply turning the bars round. It is interesting to note that, as the bars are water-retaining, the hand can be placed on them without fear of burning, when the furnace is in full operation.

The water is fed to each bar by a separate pipe under control and the whole fed from a constant-level tank provided with a ball valve. Water evaporation is exceptionally high, and there is always good direct contact between the fine ash and the water. In actual operation it is found that the front bars evaporate considerably more water than the rear ones, and the correct method of setting the tap is to see that from each bar the water drips a little, enough to keep the water-level in the ashpit fairly high.

* Abstract of a paper read before the Society of Glass Technology of Newcastle, on Wednesday, March 20, 1918, at the Mining Institute, Newcastle-on-Tyne.

The gas outlet is placed fairly low down in the side wall, by which means a fourfold purpose is served, viz.: (1) The fuel-containing capacity of the producer is unusually large, all the space above the gas outlet being so employed. (2) The height of the bed of incandescent fuel remains constant, as the incandescence cannot extend above the gas outlet. (3) Much of the dust, which in ordinary producers is usually carried away in the gas remains in the producer: and (4) The necessity for frequent fuel-charging is obviated, and in practice these advantages are found most valuable.

After the gas is made, it passes through a dust-collecting chamber. The diminishing rate of travel of the gases which is provided for causes the depositing of the dust on the large internal surfaces. The amount of dust actually collected amply proves the necessity for this dust-collecting arrangement. The dust chamber should be cleaned out about once a month through the door provided.

After the dust has been extracted from it, the gas is led to the furnace for combustion, the requisite amount of secondary air being admitted. Where furnaces of this type are constructed recuperation of gas becomes unnecessary, the whole of the sensible heat being utilised.

The recuperation of the secondary air is a very important matter on account of the temperature necessary to ensure the furnace working properly. Temperatures up to 1,200 deg. C. are quite easy, and when greater heats than this are required great care has to be taken to ensure proper recuperation and adequate control of both primary and secondary air. Of course, in any furnace the efficient regeneration or recuperation of the air is a means towards economy in fuel, but with the glass furnace, in addition to the necessity for all possible economy in fuel, it is of the greatest importance that the proper temperatures should be easily obtained and that with unfailing regularity, a condition which is fully provided for by the construction of this furnace.

The temperature necessary for properly "founding" and "fining" the metal is at least 1,400 deg. C., and this was not obtained in our experimental furnace without considerable trouble. Our secondary air was only very imperfectly recuperated, so extremely accurate regulation of the primary and secondary air is necessary. In fact, it was not till the exhaust gases were tested for their CO_2 contents that we were enabled to so regulate the furnace as to render possible temperatures above 1,200 deg. C. With the design of recuperator now arrived at, considerably higher temperatures may be looked for. Various temperatures can be obtained by shortening or lengthening the flame, and this can be brought about by the many different ways of mixing the gas and air.

It was thought possible that the tank could be worked out without the use of syphon pots, but this was found impracticable, as it upset the regulation of the primary and secondary air, and as the furnace works under a slight vacuum the air drawn in had too cooling an effect.

The exhaust gases are taken off at the opposite end of the furnace to the producer and after passing down and outside the tank, travel under it and through the recuperator to the chimney stack. The stack in use on the experimental furnace is 60 ft. high and gives an ample "pull." Easy means of regulating the "pull" on the exhaust gases is very necessary, as this governs to no small extent the admission of both primary and secondary air. In any case where natural draught is depended upon the "pull" must of course be sufficient to overcome the friction caused during the passage of the air and the exhaust gases through the apparatus. If artificial draught should in any case be more convenient, an ordinary centrifugal fan is all that would be necessary.

As to the tank itself, this is constructed of quoris made of Stourbridge pot-clay, all the rest of the brick-work being built of ordinary common firebrick manufactured locally.

The consumption of coke is at the rate of about 1 cwt. per hour, and the storage capacity of the producer is sufficient to last about 4 hours. The bars require a little attention about once an hour, but this will depend, of course, upon the amount of ash content of the coke. One of the conspicuous advantages of this construction of producer is that entirely unskilled men can be taught in a few hours to operate the plant and that its simplicity is so great as to obviate all those liabilities to getting out of order of which one hears so much in connection with many other types. The coke is used as received from the gas works, but it is conducive to good working not to use the breeze of which some little quantity is usually formed, due to the friability of the coke in carting and handling.

I sincerely hope that the information I have given, although partial and very imperfect, will be sufficient to stimulate interest in this most important subject.

COLOUR-PHOTOGRAPHY SCREENS.—A new process of making screens for colour photography was recently described in *La Nature*. It is the versicolour process of Louis Dufay. A thin sheet of celluloid is passed between two cylindrical rolls; the lower roll is plane, the upper is provided with very fine parallel ring grooves, flat on top; fine hollows are thus rolled into the upper surface of the celluloid. This surface is inked with a red transparent matter, and the ink wiped off again so that the hollows are alone left red. The ridges are then inked with blue; in this way a two-colour screen is obtained. The process may be repeated with the lower surface of the celluloid, or the two systems of rulings may simultaneously be produced. The first two colours may, *e.g.*, be yellow and blue, and the third and fourth red and green, or the four colours may be yellow, red, blue, orange. In these cases the third colour is the one missing in the first pair, and the fourth colour is complementary to the latter.

GERMAN INDUSTRIAL COMBINES AND EXPANSION.

THE Kattowitz Mining Company, which had a share capital of 39,000,000 marks, has increased that sum by 13,000,000 marks, needed for the purchase and carrying on of the Franco-Polish Renard concern. The latter, in the meantime, will remain a Gewerkschaft. With a somewhat reduced output the Renard concern at present produces 400,000 tons of coal per annum, against 600,000 tons formerly, but with a moderate outlay the production will probably be raised to 750,000 tons or 800,000 tons.

The Lahmeyer Electric Company is increasing its capital from 30,000,000 marks to 40,000,000 marks with a view to large impending peace undertakings, more especially in the matter of electric railways and plant for the production of electric energy. The company increased its capital in 1908 and in 1913, each time by 5,000,000 marks. Although the Bank for Electrical Undertakings in Zürich has sold part of its Lahmeyer shares to Germany, the bank in question probably still owns about two-thirds of the capital of the Lahmeyer concern.

The Anhalt Coal Company, Halle, is increasing its capital from 9,000,000 marks to 13,000,000 marks. Of the new shares, 2,800,000 marks will be used for exchange with 7,000,000 marks of shares in the Zeckau-Kriebitz coal mine. The balance of 1,200,000 marks in new shares will be issued at 216 per cent., the old shareholders having the first call.

Through the issue of 14,000,000 marks of new shares, recently admitted into the Berlin stock exchange, the Rhenish steel works, Duisburg-Meiderich, has been enabled materially to increase its possessions of coal mines. For the Brassert coal mine, 12,000 marks of new shares were paid in exchange for each portion (kux). Hitherto the Rhenish-Westphalian Steel Works had to depend upon the Zentrum coal mine, as its coal-fields on the left bank of the Rhine, on which 7,900,000 marks so far have been expended, have not yet been opened out. The Brassert mine raises the allotment of the Rhenish Steel Works to 1,315,000 tons of coal, 100,000 tons of coke and 144,000 tons of briquettes, the self-consumption allotment amounting to 1,100,200 tons. The Rhenish Steel Works, however, does not consider its supply of fuel ensured by the purchase of the Brassert concern, and has also acquired the French shares, 20,440,000 marks, out of a share capital of 22,000,000 marks, of the Friedrich Heinrich Company, at Lintfort, at a price of 183 per cent. The latter concern comprises about twenty minefields, and it has obtained an allotment of 1,250,000 tons of coal and 450,000 tons of coke. The Friedrich Heinrich concern is estimated to contain between 700,000,000 and 800,000,000 tons of coal.

The R. Wolf Company, Magdeburg-Buckau, a well-known concern in the machinery trade, continues its expansion. Having within the last year or two acquired the Hagan Locomotive Works, Erfurt, and the German John Fowler and Co., steam plough factory, the Wolf Company has now bought the large but not particularly flourishing Ascherleben machinery works; the Wolf Company is understood to be giving 4,250,000 marks of its ordinary shares for the 4,000,000 marks share capital of the Ascherleben concern, which is considered a good price for the latter, although the war had benefitted the Ascherleben Company considerably. The Wolf Company will only issue 1,750,000 marks of new shares to complete the deal, its capital thereby being increased to 13,750,000 marks, principally held by the Wolf family.

The Neckarsulmer motor factory is increasing its capital of 2,400,000 marks, whereby it will be raised to 6,000,000 marks, but as the new shares will have to be issued "with agio," according to the new regulations, the increase of capital will be considerably in excess of the nominal amount of its shares.

The Th. Goldschmidt Company, Essen, has decided to increase its capital from 15,000,000 marks to 17,000,000 marks. Of the new shares, a number is to be set aside for the purchase of the Petroleum Industry Company, and the balance will be disposed of at a minimum price of 200 per cent. The company controls some patent rights for coal exploitation, which have been experimented with for some time, and are expected eventually to prove of material industrial importance.

The Borliner Telephone factory, Hannover, has increased its capital from 5,000,000 marks to 7,500,000 marks, the new shares to be issued at an exchange of 195 per cent.

The Hansa Lloyd Works are again increasing their capital from 14,000,000 marks to 20,000,000 marks at an exchange of 160 per cent. The concern as at present constituted, dates from 1913, when it was started with a capital of 4,400,000 marks, which was first increased to 10,000,000 marks for the purchase of the North German Motorcar Works in Bremen, and subsequently to 14,000,000 marks. For the purpose of further extension of the works, additional land has been secured.

The German Rock Oil (Erdöl) Company is a very enterprising concern which is extending its business and its possessions in different directions; this necessitates an increase of capital, and it has been stated that the present capital of 30,750,000 marks is to be about doubled by the issue of 30,000,000 marks of new shares. The company has recently acquired the Rositzer Lignite Works and the Regiser Coal Works; it has, further, acquired the Ramsdorfer Lignite Works, and also intends to secure the coalfields at Bauersberg (which belong to the State of Bavaria), for gas production purposes. In order to assert its position within this domain to a greater extent, the company has secured the control of the German Generator Company. Of considerable importance is also the acquirement of the shares of the International Roumanian Petroleum Company from Dutch owners. All these extensions entail a heavy outlay, even if the increase of capital referred to may not be necessary. Much will also depend upon what compensation the company may receive from Roumania for the damage done to works there, in which the company is interested, and the damage done to the Steana Romana concern alone is estimated at 100,000,000 Lei. Under the present circumstances, any compensation is more likely to take the shape of concessions or property, the exploitation of which will again require additional capital, besides that needed for the repairing of the damaged works. It may be mentioned, in this connection, that a year ago the German Rock Oil Company and the Steana Romana Company started borings in unexploited fields of the Roumanian State, and the results have been so promising, that these new borings also may be reckoned with in connection with the future petroleum supply of the Central Powers.

Another large concern, that of the Scheidemandel Company, seems bent upon extensions and acquirements. Last year it secured the German Spratts Patent Company, and has also secured a share in the Liebig Extract of Meat Company, Antwerp, and the glycerine factory, Mannheim. The Wilhelmsburg Chemical Works have also been combined with the Scheidemandel Company. As far as the Bavarian business is concerned, this has passed under the control of the Central Company for Chemical Industry, all the ordinary shares of which are held by the Scheidemandel Company. The latter, besides what may be called its legitimate business, has also acquired the Mannheim Manure Company, the Fattinger Albumin Company, in Vienna, and the Animals Product Company, in Frankfort. The Scheidemandel Company is further interested in the "All Germany Bone Purchase Syndicate," and in other concerns.

Among the many concerns contemplating increase of capital, that of the Machinery Company, Karlsruhe, may be mentioned, but there is a host of other companies, large and small, which are negotiating with the authorities for an increase in capital. The exchange at which new capital may be issued is in many cases a serious difficulty, inasmuch as many boards on such occasions seem to favour the shareholders more than the company. As a result, the rate of exchange of issue has in many cases to be raised, thus, the Uerdingen Wagon Company had to raise the exchange from 107½ per cent. to 157½ per cent., the Berlin Telephone Company, from 162 per cent. to 193 per cent.; the East-Elbe Spirit Works, from 150 per cent. to 200 per cent.; and the Breslau Spirit Company even from 110 per cent. to 300 per cent., the issue of capital in consequence, being reduced from 4,250,000 marks to 1,450,000 marks. A number of companies, amongst them the large Adler Motor Car and Cycle Company, are experiencing material trouble in arriving at an arrangement with the authorities, whilst an unprecedented number of companies are increasing their capital just up to the allowed limit, 300,000 marks, and a number of new companies are likewise being formed within the same margin. It should be noticed, that only one issue within the allowed limit of 300,000 marks is permitted, and this in itself is, of course, a small amount.

DEARTH OF LUBRICANTS IN GERMANY.—The dearth of lubricants, and their high prices, have not only put machinery to severe trials and rough use, but it is believed that many of the frequent small fires which have recently occurred in industrial plants must be ascribed to overheated bearings.

CORROSION OF LEAD ROOFING.—Two cases of corrosion of lead roofing were brought before a recent meeting of the Society of Chemical Industry, by Professor J. S. S. Brame. In the first case lead sheets had been put on the wood foundation of a building probably more than 200 years ago. Serious corrosion and perforation had occurred in some places, in which thick white crusts, practically of commercial white lead, were found beneath the corroded parts. The corrosion was confined to places where the lead had been in contact with oak beams, while the lead resting on pine wood had remained unaffected. This observation seems to be in accordance with the belief that oak (oak coffins, *e.g.*) corrodes lead more than other wood does; this belief is not shared by the builders of sulphuric acid chambers, however, and the original condition of the wood, whether green or seasoned, may be of more importance than the kind of wood; but Professor Brame mentioned that iron nails were always affected when used in oak fencing. In any case the condensation of moisture on the wood would favour corrosion, as Dr. Walter Reid pointed out. On the other hand, Mr. F. Southerden reports in the *Journal of Chemical Industry* of March 30, that the lead roof of Axminster Church, relaid with its oak boarding in 1909, was last year found thickly coated with a yellow-white deposit, whilst the lead of the nave roof, laid on deal in 1833, was still in good condition. In the second case lead had been laid on coke-breeze concrete, and the peculiarity was that, within 15 years or less, particles of a thick crust of a red substance had accumulated. The analyses showed the presence of about 90 or 96 per cent. of PbO, 9 per cent. of Pb_2O_3, 13 per cent. of Pb_3O_4; the occurrence of the higher oxides of red lead in such corrosions is quite unusual. The coke-breeze concrete consisted of 8 parts of breeze and 1 part of Portland cement, the free lime or free alkali of which would attack the lead. Dr. S. Miall suggested that calcium plumbite was formed in the first instance, which would subsequently be decomposed with formation of red lead. Other speakers referred to the traditional disinclination of plumbers and also of electrical engineers to bring lead in contact with cement, mortar, lime and plaster. It may be inadvisable; but how are new lead pipes to be introduced into houses when all these materials are to be avoided?

SOCIETY OF GLASS TECHNOLOGY.

At the annual general meeting, held on April 17, in the University of Sheffield, the president, Mr. Frank Wood, gave his presidential address. He began by reviewing the state of the glass industry at present as compared with its pre-war condition. The industry could be divided into eight important manufacturing sections, namely: (1) Table and decorative ware; (2) plate and window glass; (3) optical glass; (4) chemical and scientific ware; (5) electric bulbs, &c.; (6) pressed ware; (7) common glass bottles and jars; (8) flint glass bottles and jars. In the table and decorative glass trade, the British, he said, were supreme in pre-war days in quality of production. The plate and window glass trade had been well maintained during the war, and was developing. The position as to optical glass was hopeful. The highly important branch of chemical and scientific glass ware was non-existent in this country before the war. Now this type of glass ware could be produced in this country in bulk, and equal in standard to the best German, but protection was necessary to preserve this trade. The production of electric bulbs had developed enormously during the war, and the same might be said of pressed glass ware. By far the largest section of the glass industry was the production of common glass bottles and jars. Manufacturers had risen to the occasion and the help of improved machinery has supplemented output. The signs in this branch of the glass trade were very healthy. The same might be said for the flint glass and jar section.

After pointing out the valuable assistance rendered by the Glass Technology Department of the University of Sheffield to the glass trade, and after voicing a warm eulogy of Dr. W. E. S. Turner, the president, stated that he had every confidence in the future of the glass industry. After a sleep of fifty years, broken at times by many bad dreams, it had at last awakened.

The concluding portion of the address was a valuable contribution to the study of devitrification in glass. As is well known, tank furnaces are subject to devitrification on a large scale, this devitrification being known as "dogging." The formation of "dog" in reason is good, as it serves to protect the tank bottom. "Dog" in excess is very bad, as it gives rise to many difficulties and causes losses in output. The two best methods of preventing the formation of "dog," which is chiefly calcium silicate, are (1) to increase the proportion of alkali in the batch, and (2) to increase the proportion of alumina. The second method is to be preferred as an increase of alkali means an increased attack on the sides and roof of the tank, and also the formation of a less durable glass. The addition of alumina not only helps to prevent "dogging," but it means less attack on the tank walls and the production of a more durable, tougher glass. For dark bottle glass sufficient alumina may be added by mixing with every 100 parts of batch, from 5 to 6 parts of ground red brick. For light-green bottle glass ground felspar should be substituted for the brick. Specimens of glass, melted by Miss A. M. Jackson, B.Sc., were shown, to indicate the beneficial effect of felspar on bottle glass.

Mr. G. V. Wilson, B.Sc., F.G.S., then read a paper entitled "Notes on the Formation of Certain Rock-forming Minerals in and about a Glass Furnace." The paper was one of the most important ever read before the society, and many of the results when applied in works practice will be of vital importance. By means of a large number of slides the author showed the formation of various types of crystals in glass. He then went on to deal with the question of the effect of heat upon glass pots and furnace blocks, and showed by a wonderful collection of slides and diagrams the various effect of the different constituents of fireclays upon the life and durability of a glass pot or tank. A full discussion of the various changes which take place was given, and parallels with natural processes were drawn. A set of microscopic slides and a numerous collection of specimens enhanced the value of the lecture, which was followed by an animated discussion.

The next meeting of the society will be on May 15, in London.

THE GERMAN LONG-DISTANCE GUN.—We learn from reliable sources that the constructor of the new giant gun is the Artillery Director of Krupps, Professor Dr. Fritz Bausenberger, born in Frankfort-on-Main, who is already well known by his 42 cm. mortar. According to his ideas, calculations and proposals, the gun was constructed by Krupps by order of the Admiralty. Director Rausenberger, who is a Major in the Reserves, was present when the first shot on Paris was fired. Great assistance in the calculation of the trajectory of the new gun has been rendered by Otto von Eberhard, formerly a pupil, and now assistant, to Bausenberger, who was also born in Frankfort.

ELECTRIC SHIPBUILDING CRANE.—Messrs. Stothert and Pitt, Limited, have at the present time temporarily erected, and working at their Bath establishment, one of a large installation of electric shipbuilding jib cranes, intended for the new standard shipbuilding yards at Chepstow, in the Bristol Channel. These cranes mark a distinct advance in the development of lifting machinery for shipyard work. The cranes each lift a working load of 4 tons at a maximum radius of 105 ft., and are mounted on a high tower, the jib-head pulley at the maximum radius being 110 ft. above ground. One feature of the cranes is that the load is luffed in a horizontal line from the maximum radius of 105 ft. to the minimum of 25 ft. by means of the "Toplis" patent system.

CATALOGUES.

Electric Resistance Nets.—A resistance and heating material of asbestos and woven wire in net form is shown by sample and illustration on a card that comes from the Cressall Manufacturing Company, 40, Staniforth-street, Birmingham. It is of British manufacture, and made to suit all the many uses to which it may be put.

Electric Lamp Reflectors.—A catalogue containing a great deal of generally useful information about lighting factories, workshops, &c., and describing a series of metal reflectors, with all required fittings, comes from the British Thomson-Houston Company, Limited, 77, Upper Thames-street, E.C. 4., who will send copies free on application.

Lubrication.—A catalogue giving a full technical description, with illustrations, of the vertical gas engine and the various gas-producer plants, comes from the Vacuum Oil Company, Limited, Caxton House, S.W. 1. The special object is to bring forward the company's lubricating oils, which are specially and accurately adapted to various purposes; and this object is served by giving practical information which will be useful to engineers.

Locomotive Engines.—The eight driving-wheel type is the subject of an interesting historical essay by Mr. J. Snowden Bell, issued in the catalogue series of the Baldwin Locomotive Works, Philadelphia, U.S.A. The Wylam engine in use before 1825 and the Ross-Winans engines of 1843 and 1844 are illustrated and described, followed by various improvements leading to the engines now principally used for heavy freight and passenger service in the United States.

Paraffin Vapouriser.—The method of efficiently vapourising paraffin or kerosine, so that it may be used as engine fuel for motor vehicles, has been the subject of careful study and experiment by Messrs. John I. Thornycroft and Co., Limited, of Southampton and Caxton House, S.W. 1. This vapouriser is illustrated and described in a special catalogue just to hand. It presents a simple and easily-controllable mechanism. The working directions are clear, but they frankly emphasise the care and attention required to obtain satisfactory results. Motor vehicle owners, engineers and drivers will find it a useful catalogue.

Steam Jointing.—Under the name of "Topolite," Messrs. Frank Morris and Co., of 101, Leadenhall-street, London, E.C., have put on the market a jointing material which is claimed to be the equivalent of the Austrian material "Klingerit." It is made in sheets, 48 in. square, and in thicknesses of $\frac{1}{32}$ in., $\frac{1}{16}$ in., and $\frac{1}{8}$ in. It is stated to resist the action of superheated steam, dry heat, alkalis, acids and gases. The same firm make a Topolite stuffing-box packing, containing strands of metal wire and a fibrous lubricant, and also a second quality of jointing material. All these are described in leaflets which we have received.

Steam Hammers.—About 20 steam hammers, from 1¼ cwt. to 5 tons, of arch and overhung types, are described in a catalogue received from Messrs. B. and S. Massey, Limited, Openshaw, Manchester. They are adapted for cogging and tilting tool steel; that is, respectively, for reducing the cast steel ingots to a suitable size for tilting or rolling and for finishing to the required section. Full information is given as to the construction and operation of the hammers and the size of work for which each is suitable. Steam hammers should be much more largely used even in comparatively small works, and especially for tool steels. When tools wear short they can be hammered out to smaller sections of adequate length and the material is improved if carefully hammered at the proper heat.

Aeroplane Work Furnaces.—Over a dozen gas furnaces specially suitable for aeroplane works are illustrated in a catalogue from the Richmond Gas Stove and Meter Company, Limited, Warrington. The annealing of small parts, the treatment of wires in length, the hardening and tempering of tool noses, cutters, dies, &c., are each specially provided for in most convenient and economical ways. We are glad to see that easy provision is made for heating up high-speed tools slowly before the precise maximum heat is attained. All these furnaces show that the designers have studied the working requirements of the engineer.

Steam Engines.—The slow speed horizontal engine has its own peculiar field of work and a very wide one. In the catalogue now before us, issued by Messrs. Cole, Marchent and Morley, Bradford, all the parts are fully described and illustrated and a list of standard patterns and powers is given with full details. Generally, the engines show careful modifications as compared with the medium speed type described in these notes of January 11 and made by the same firm. "Slow" speed means 75 r.p.m. to 120 r.p.m. in engines from 1,600 normal indicated horse power to 340 normal indicated horse power. There are four types, all compound, all for steam pressures up to 150 lb. to 160 lb. with superheat and with 10 to 18 sizes within the limits stated. These engines would be very economical, durable and reliable for general mill and factory drives.

Engine Dynamometer.—A pair of arms fixed to a boss and carrying paddles may be revolved on an electric motor shaft and the power required to drive the paddles at various speeds against the resistance of the air carefully measured. If the paddles are adjusted to various distances from the centre of revolution, and various sizes of paddles used, the results may be plotted on squared paper and a series of curves drawn. The paddles, or fan brake, may then be attached to any engine and by counting the revolutions and referring to the curves the horse-power developed can be read at a glance, or worked out more exactly by a simple equation. This is the principle of the Walker fan brake (Patent 100556) described in a catalogue issued by Messrs. W. G. Walker and Co., Emery Hill-street, Victoria-street, S.W. 1. The size of fan brake dynamometer for engines of 60 h.p. can be packed in a box measuring, outside in inches, 20 by 9 by 4. The horse-power absorbed by this instrument is, at 700 r.p.m., 20 h.p., at 800 r.p.m. 30 h.p., at 1,000 r.p.m. 57 h.p. The instrument is made in a full variety of powers for loads of under 1 h.p. to 150 h.p. and speeds of 100 r.p.m. to 5,000 r.p.m. A special type for aerial engines is made in five sizes, covering speeds of 500 r.p.m. to 1,600 r.p.m. and powers up to 500 h.p.

Hydraulic Transmission of Power.—In these systems one of the main objects is to find a pump which (while being continuously driven at constant speed in one direction, will deliver a flow that is easily variable in capacity and reversible in direction. In the Carey Transmission System the pump may be described as consisting of three parts: (1) An outer casing in which (2) a rotor is journalled and (3) a moveable ring between rotor and casing. Thus we have in appearance the usual rotary pump arrangement with an eccentric space; but, owing to the ring being moveable, the space may be changed to top or bottom position, or any intermediate position including the concentric position. The rotor contains five cylinders, with axes radially disposed, in each of which a ball reciprocates, acting as a piston. The ring has a ball race on its internal surface and on its outer surface a screwed bolt which projects through the casing and by which it may be moved up or down. One end of the rotor shaft projects through the casing to take the driving connection, and the other end forms a flat valve face with five holes, one from the inner end of each cylinder. The valve end rotates against a plate with two port holes, this plate being formed on or fixed to the outer case end. These ports serve for suction and delivery alternately in accordance with whether the movement of the ring leaves the eccentric space at top or bottom. The balls get their outward (suction) strike by centrifugal force but each is allowed to make this stroke only as it passes from the minor to the major space and is forced to make its return (pressure) stroke as it passes from the major to the minor space. Each ball piston, therefore, makes both a suction and a delivery stroke during every revolution of the rotor; the stroke will be greater or less in length in proportion to the eccentricity of the ring to the rotor; the stroke will be *nil* at concentric position, and the flow will be reversed as the major space is reversed. Obviously, the screw projecting from the ring can be made for quick or slow movement and by hand gear or turned mechanical gear, so as to serve a motor lorry or a planing machine. The catalogue, which comes from variable Pumps and Motors, Ltd., 222, Great Dover Street, London, S.E. 1., does not deal with pump efficiency but this should be fairly high if the ball pistons do not leak. The pump can be adapted to many transmission and other uses. It is very compact, simple and capable of being made very durable. The variation of power and reverse action is smoothly obtained. It can be adapted also as a motor operated by a constant pressure flow. It is interesting even in a branch of mechanics so rich in interesting inventions.

TEMPERATURE DETERMINATION BY EUTECTIC ALLOYS.—In the course of an investigation on steam turbine alternators in the laboratories of the General Electric Company at Schenectady it was desired to determine the maximum temperature arising at the rim of a steel disc rotating at very high speeds. As the centrifugal forces precluded the attachment of ordinary temperature-measuring devices to the rotors, it occurred to Dr. C. P. Steinmetz to drill small holes into the rim and to fill them with metals or alloys of known melting-points. When a metal melted, it was partly thrown out of its hole, and when one metal melted, and another did not melt, the temperature of that part of the rim would lie between the temperatures of the two melting points. As the melting points of suitable metals lie rather far apart, Steinmetz made use of eutectic alloys. They are available in great variety, and have the advantage that their melting points are less dependent upon purity than those of pure metals. In his communication to the American Chemical Society (Journal, 1918, pages 96 to 100) Steinmetz deals particularly with this feature. He points out that a eutectic alloy, containing an excess of one or the other constituent, would in cooling deposit crystals of that metal, and the alloy would thus thicken before solidifying, but the final freezing-point would practically remain that of the eutectic. Similar considerations would hold for the melting-point, and he tested this by experimenting with quarternary alloys of bismuth, lead, tin and cadmium, in various proportions. The alloy containing these four metals in the proportions 15 : 8 : 4 : 3 is known as Wood's metal, and melts at 60·5 deg. C.; other alloys of the constituents have higher melting points, and by further adding thallium and zinc to his metals, Steinmetz obtained 12 alloys of two or more metals ranging in melting points up to 194 deg. C. It was found that slight excesses of one or the other constituent hardly affected the melting-point of an alloy, though the flat portion on the curve became less long and less distinct, and a great tendency to under cooling had to be counteracted by stirring. Thus the limited use at present made of eutectics for temperature measurements could considerably be extended probably. In the case of steam turbine rotors, to which Steinmetz does not further refer, temperatures of over 300 deg. C. may arise and other alloys would have to be used, and pressure influences might have to be allowed for.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c. of the Communicators are given in italics.

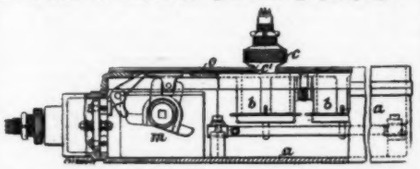
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

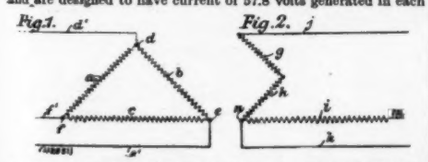
ELECTRICAL APPARATUS.

112,664. N. J. Austin, Forest Hill, London, and G. E. Taylor, London. Electric Couplings. (3 *Figs.*) January 18, 1917.—This invention relates to apparatus in which the controlling switch is interlocked with the coupling plugs in such manner that the plugs cannot be inserted in or withdrawn from their sockets while the switch is closed. According to this invention, a series of sockets *b* adapted to receive coupling plugs *c* are mounted in a case or box *a* having a locking slide or sliding cover *o* with keyhole slots arranged to engage reduced portions *c1* of the bodies of the removable parts of the plug couplings and



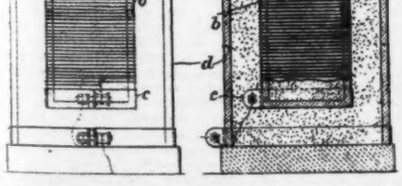
operatively connected with the switch *m*, which, in the closed position, moves the locking slide *o* into a position in which it locks any previously inserted plugs in their sockets and prevents the insertion of any plugs while the switch is closed, only permitting the plugs to be inserted or removed when the switch is open and the current supply cut off. The controlling switch, which is located in the same case as the plug sockets, is itself prevented from sparking by use of oil or other insulating liquid in a known manner, and is operated by the rotation of a removable key. (*Sealed.*)

112,681. The British Electric Transformer Company, Limited, and R. Crosbie-Hill, Hayes, Middlesex. Transformers. (2 *Figs.*) January 15, 1917.—This invention has reference to the transformation of a three-phase current into a two-phase current, or *vice versa*, at equal or different potentials. The three coils *a*, *b* and *c* in the delta connected set are arranged to have three-phase currents produced therein or supplied thereto, such that there will be a voltage of 100 between any two of the three points *d*, *e* and *f* of connection between the coils which are connected to the conductors *d1*, *e1*, and *f1*. Two of the three series connected coils *g*, *h*, *i* to form the secondary two-phase system, namely, the coils *g* and *h*, are arranged to be inductively acted upon by two of the delta connected coils, namely *a* and *b*, and are designed to have current of 57.8 volts generated in each



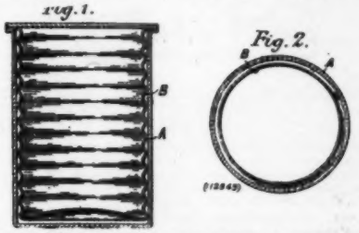
of them, the third coil *i* in the said series-connected set being arranged to be inductively acted upon by the third coil *c* of the delta-connected set and to have current at a voltage of 100 generated in it, the phase of the E.M.F. generated in it differing from that in the combination of the other two coils of the set by 90 deg. *j*, *k* and *m* are the conductors connected to the three series-connected coils *g*, *h* and *i*, respectively, the intermediate conductor *k* being connected to the set of coils at a point *n* between the third or last-mentioned coil *i* and the next series coil *h*. By this means a two-phase current will be obtained, and there will be a difference of an E.M.F. of 100 volts between the said intermediate conductor *k* and each of the other two conductors *j* and *m* connected to the ends of the series set of coils. (*Sealed.*)

112,731. L. W. Wild, and E. P. Barfield, Westminster. Electrical Furnace. (2 *Figs.*) June 26, 1917.—This invention has for its object to provide an improved form of furnace designed



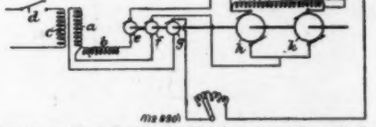
for hardening steel, and wherein a crucible is employed which contains molten salt in which the substance to be hardened is immersed, and to this end a furnace constructed according to the invention comprises a silica crucible or tube *a* with its lower end closed and wound with a suitable electrical conducting material, such as nickel-chrome wire *b*, and the ends of the winding are anchored to metal bands *c* surrounding the said crucible or tube. This winding is connected to any convenient source of current supply, and the current heats the wire and hence the salt contained in the silica crucible *a*. The coil or winding extends from the bottom of the silica crucible for a portion only of its height so as to leave its upper part clear. The silica crucible is contained within an outer casing *d*, with an intervening space between the two, and this space is filled with any suitable heat and electrical insulating substance, such, for example, as quartz powder, and the metal bands on the crucible are electrically connected to similar bands *f* around the said outer casing and in connection with a source of electrical current. (*Accepted January* 30, 1918.)

112,845. R. W. Gregory, Newcastle-upon-Tyne, and A. Reyrolle and Co., Limited, Hebburn-on-Tyne. Oil-break Electric Switches. (8 *Figs.*) February 22, 1917.—This invention relates to tanks for oil-break electric switches. A tank, according to the present invention, comprises an outer vessel and a separate inner container, the inner container being so formed as to be capable of expanding under the influence of sufficient internal pressure. The tank shown is circular in cross-



section, the outer vessel A being cylindrical, and the inner container C corrugated. The inner container is dished or concave at the bottom. In some cases the inner container need not stand on the bottom of the outer vessel, but may be suspended in the outer vessel by its flange, a small space or clearance being left at the bottom to allow for expansion in a downward direction. The outer vessel has a plain cover, but it will be understood that the switch gear and other fittings are mounted thereon in the usual manner. (*Sealed.*)

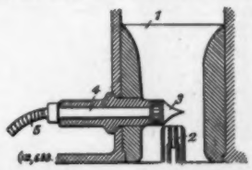
112,890. R. Pohl, Bradford. Alternating-Current Machinery. (3 *Figs.*) June 9, 1917.—The invention relates particularly to that type of alternating-current motor known as the self-starting synchronous motor, and provided with primary and secondary wound members, in the latter of which a direct current is superimposed upon the induced alternating currents for the purpose of pulling the rotor into synchronism. Difficulties have been experienced in starting, especially in cases in which a powerful starting torque is required in bringing about correct and gradual superposition of the direct current upon the alternating current so as to avoid discontinuity in the starting torque characteristic. For this purpose, according to the present invention, a three-wire dynamo electric generator is employed as the exciting machine and the point of connection of its middle



wire is joined to the neutral point of the secondary winding of the main motor. The secondary winding of the motor is a two-phase winding *a*, *b*. The primary winding is shown conventionally at *c*, and is connected to the supply through switch *d*. The secondary member is the rotor, and the windings *a*, *b* are connected in the usual way to the three slip rings *e*, *f*, *g*. The slip ring *f*, connected to the neutral point of the windings *a*, *b*, is joined directly to the mid-point of the three-wire generator. This generator is constituted by two equal armature windings *h*, *k* in series. As the speed of the motor increases direct current from the armature *h*, *k*, is superimposed upon the two-phase current. The induced alternating current in the windings *a*, *b*, of course, gradually dies out as the machine is pulled into synchronism, leaving the direct current at full strength. (*Accepted February* 6, 1918.)

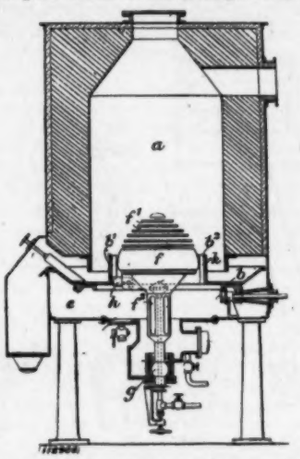
GAS ENGINES, PRODUCERS, HOLDERS, &c.

112,683. F. W. Hopper, Glasgow. Carburettors. (3 *Figs.*) February 5, 1917.—This invention relates to carburettors for internal combustion engines of the type fitted with an atomising device in the form of a fluted cone disposed within the mixing chamber in the path of the jet. According to the invention, the fluted cone is mounted on a spindle which



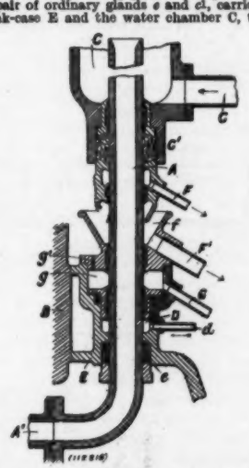
extends to the outside of the mixing chamber, and is mechanically driven, for example, by means of a flexible cable. As shown in the drawing, there is fitted within the mixing chamber 1, immediately above the nozzle 2, an atomising device 3 formed as a fluted cone mounted on a spindle 4, which is mechanically driven, for example, by means of a flexible cable or transmission element 5, (*Accepted January* 30, 1918.)

112,909. F. Thuman, Westminster. Gas Producers. (3 *Figs.*) September 25, 1917.—This invention relates to gas producers for the manufacture of producer-gas, or water-gas, of the type in which the ashes and clinker formed from the combustion of the fuel are mechanically removed from the base of the producer by a rotating ash pan upon which is usually mounted the grate projecting into the fuel-bed and serving as an air and steam distributor, and as an ash crusher, the grate being eccentrically arranged in relation to the fuel chamber and rotating with the ash pan. *a* is a cylindrical firebrick-lined fuel chamber; *b* is the ash pan rotated about the axis of the fuel chamber and having an eccentric aperture surrounded by an upwardly-extending crushing ring *b1*. A gastight chamber *c*, forming an extension of the fuel chamber *a*, encloses the grate, ash pan and gearing. *f* is the grate with outlet ports *f1* at different levels and with a hollow stem formed with inlet ports *f2*; the grate *f* is anchored by means of a ball joint *g* at the bottom of the producer; and the centre of the ball *h* is on the rotating axis of the ash pan *b* so that the axis of the grate is at an angle to



the axis of rotation of the ash pan, with the result that as the ash pan rotates a gyratory movement is imparted to the grate at all times, whether it be made to rotate with the ash pan by means of a pivoted bolt or dog *h* or not. Ribs *b2* formed on the interior of the crushing ring *b1* bear against the grate *f*, forming air spaces *k* around it; the bolt or dog *h* engages one or other of these ribs. A grinding effect is obtained between the outer surface of the grate *f* and the inside of the crushing ring *b1* of the rotating ash pan when the grate is disengaged from the ash pan; this grinding is useful in keeping the spaces *k* clear of clinker and ashes for free access of air and steam to the fire (*Accepted February* 6, 1918.)

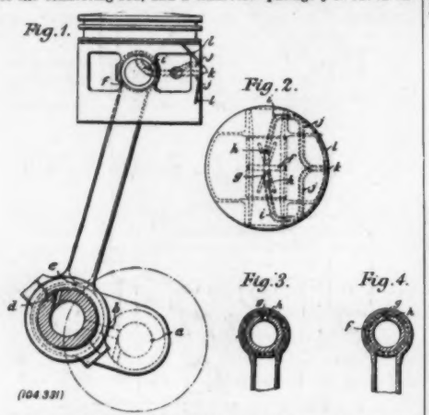
112,816. [Vickers, Limited, Westminster, London, J. McEachnie and W. F. Rabbidge, Barrow-in-Furness. Internal-Combustion Engines. (1 *Fig.*) January 25, 1917.—This invention relates to the supply of cooling water to the moving parts of internal-combustion engines. According to this invention, the sliding pipe or conduit through which the cooling water enters or escapes passes through a stuffing-box or gland packed with oil or grease under pressure. A is the sliding or plunger pipe fitted to the lower end of a downwardly-projecting connecting pipe A1 leading from the base of the piston and extending under the edge of the cylinder B. C is a water chamber into which the upper end of the pipe A extends, water being supplied or exhausted through the pipe *c*. D is the oil gland supplied with oil or grease under pressure through the pipe *d*. The plunger pipe passes through a pair of ordinary glands *e* and *e1*, carried respectively by the crank-case E and the water chamber C, the latter con-



taining a cushion of air. Below the upper or water chamber gland *e1* a water drain F is provided serving to lead away most of the water carried through the gland, a conical water catcher *f* receiving any leakage past the drain F and carrying it off by a second drain F1. The oil gland or stuffing-box D is placed immediately above the lower ordinary gland *e* so that any downward leakage that may occur through the latter gland consists only of oil, while above the oil gland D a water and oil drain G is provided, preferably immediately below the water catcher *f* above referred to, upward leakage of oil passing into the chamber *g* of this drain, where it meets any water which may be carried past the water catcher *f* by the plunger pipe A. The water and oil can be collected and the oil separated in the usual manner. The chamber *g* may be provided with vent holes *g1*. (*Sealed.*)

104,331. Societe Lorraine des Anciens Etablissements de Dietrich and Cie., de Luneville, Paris, France. Internal-Combustion Engines. (5 *Figs.*) January 26, 1916.—This invention relates to internal combustion engines, and it has for its object to provide an apparatus for assuring an efficient lubrication of the bearing surface of the piston upon the cylinder during a portion of the power stroke. The general lubrication of the engine is effected under pressure. On reference to Figs. 1, 2,

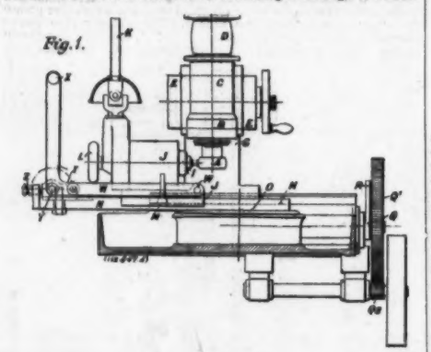
3 and 4, it will be seen that the oil, which is drawn from any suitable reservoir, serves to lubricate first the bearings of the main shaft, and is then forced into the interior of the said shaft through the holes *a*. Thence the oil passes through the passage *b* into the pins of the connecting rod, and through the orifice *d* it effects the lubrication of the connecting-rod ends and their pins, then passes through the passage *e* inside the shank or body of the connecting rod, or in the case of a connecting rod having the form of a double T, through a pipe extending along the shank of the connecting rod, so that the said oil is brought up to the small end of the connecting rod in order to effect the lubrication of this end of the connecting rod on the piston pin. This oil serves to lubricate the bearing surface of the piston, and for this purpose an annular groove *f* is cut in the brass of the small end of the connecting rod, and a transverse passage *g* is cut in the

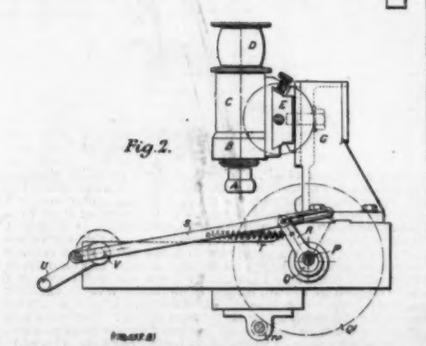


upper part of the small end of the connecting rod. The piston-pin is pierced with two holes *h*, in which are fitted pipes *i* communicating with pipes *j*, which open at the bearing surface of the piston at *k*. During the compression period, the transverse passage *g* does not communicate with the holes *h* pierced in the piston pin and communication begins to be established at the moment when the piston passes through the upper dead centre, and it is kept open during a fraction of the exhaust stroke, that is to say, during a fraction of the period during which the piston is loaded, in such a manner that the oil admitted to the transverse passage *g* through the grooves *f*, will enter the pipes *i* fixed to the piston pin, and reaches thence the outer wall of the piston, and is distributed along the oil grooves *l* which are formed in the said wall. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

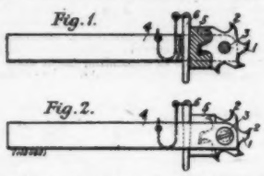
112,647. Adam Hilger, Limited, and F. Twyman, London. Grinding or Polishing Machines. (2 *Figs.*) July 9, 1917.—This invention relates to machines for grinding or polishing. A grinding tool A is mounted on an axis B carried in a boss C and revolved by means of a belt passing round a pulley D. The boss C is mounted upon a slide E. The slide E is carried by an angle-piece G fixed to the frame of the machine. The work-holder I is revolved in a bearing J through a flexible





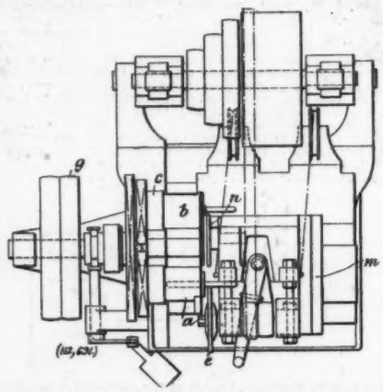
shaft K. When it is desired to mount or unmount the work, the work holder is withdrawn by a hand wheel L. The bearing J is secured by a clamp M to a carriage N mounted upon a worm wheel O driven by means of a worm P carried in an eccentric bearing Q, and driven through a wheel Q1 and pinion Q2. Upon the bearing Q is an arm R whose end extends into a slot in a bar S, to which bar it is connected by a spring T. The bar S is pivoted to a handle U, which is pivoted to the frame of the machine at V. To the bearing J is pivoted one end of a link W, whose other end is pivoted to a bell-crank lever X pivoted at Y to the carriage N. When it is desired to withdraw the work-holder the clamp M is loosened and the handle X pulled downwards, by which means the link W is actuated and the bearing J is withdrawn. The working position of the work-holder is determined by the position of the pivot Y, which can be adjusted by means of a screw Z. (*Sealed.*)

112,692. A. Macarthur, Johnstone, Renfrewshire. Lathe Cutting Tool. (3 *Figs.*) March 1, 1917.—The subject of this invention is an improved cutting tool for lathes of the kind in which the tool proper is provided with a plurality of cutting edges and is circularly adjustable in the tool-holder to bring the selected cutting edge into operative position. A tool, according to the invention, comprises a tool proper composed of high-speed steel and formed with a plurality of arms 1 having cutting edges 2, the tool proper being circularly adjustable on



the screw-pin 3, to bring the selected edge into operative position. The tool proper is accommodated in the jawed end of a tool-holder 4, the jaw being traversed by the screw-pin 3 and serving to receive a packing block 5 of I-section, which may be temporarily locked in position between the tool proper and a removable cotter-pin 6. In practice the tool proper may be formed with, say, six radiating arms 1, each having a cutting edge, such as 2; the packing block 5 being formed with pockets entered by the rearward arms. (*Sealed.*)

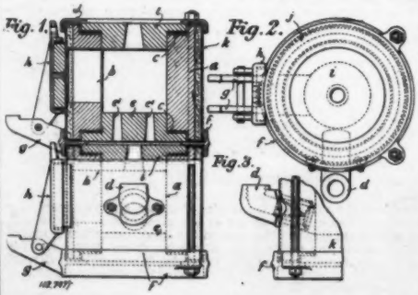
112,691. E. M. Mitton, Birmingham. Grinding and Milling Tools. (3 *Figs.*) February 27, 1917.—This invention relates to grinding, milling and like machine tools of the type wherein the feed of the tool-carrying slide is controlled by means of a pattern of the work piece to be produced. A pair of chucks *a*, *b* are arranged in parallel in a double headstock *c*, the chuck *a* being adapted to hold a knife by the blade part and with its handle projecting to be operated upon by the grinding wheel *e*, whilst the chuck *b* holds the pattern in a similar manner. The chucks are rotated from a belt pulley *g* through suitable gearing. The grinding wheel *e* is mounted on a spindle carried on a slide *m*;



the latter also carries a guide wheel *n* adapted to make contact with the pattern. The grinding tool is kept up to its work and the guide wheel to the pattern by the action on the slide of springs or weights, but by the rotation of the pattern and its action on the guide wheel together with the action of the weight or spring, a reciprocatory motion is imparted to the slide, such as will cause the grinding wheel to grind the knife handles to the required oval or other shape corresponding with the pattern. In addition to the aforesaid reciprocating motion of the slide, which is in a transverse direction relatively to the axes of the rotating work and the pattern, a longitudinal motion is also imparted to the slide (*Sealed.*)

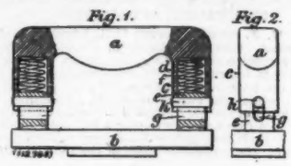
MINING, METALLURGY AND METAL WORKING.

112,747. J. M. Wallwin, Warwick. Gas-heated Furnaces. (3 *Figs.*) September 4, 1917.—This invention relates to gas-heated furnaces as used for treating metals. Each body part *a* of the furnace comprises a tubular section of refractory material, formed with an opening *b* giving access to the interior. The ends of the sections are recessed at *c* and the bottom section *a*



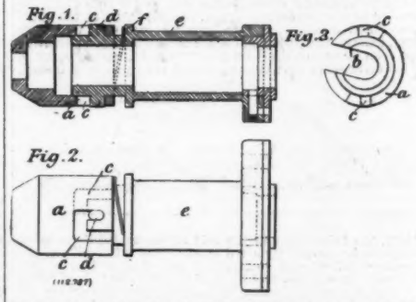
is formed with an opening to admit the gas burner *d*. A flanged blank *e* of refractory material is fitted in said bottom section *a*, and rests upon the web of the metal flange *f*. The latter is formed with ears *g* to which is hinged the door *h* adapted to open downwardly and rest upon the extremities of the ears *g*, which act as supports for the same. The flange or ring *f* also constitutes a base upon which the furnace rests. The top of each section *a* is provided with a blank *i* of refractory material having a central outlet aperture and between the two sections *a*, a second flange or ring *f* is provided, similar in all respects to that above described, and carrying the door for the top furnace. Instead of a plain blank for the bottom of the latter, a blank *e* is provided, having inlet apertures *e1* lying to the side of, or around the central aperture of the adjacent blank *i*. A plain flange *j* is provided at the top and the flanges *f* and *j* are formed of sufficient size to accommodate metal casings *k* between which, and the body part, a silicate of cotton packing is placed. (*Sealed.*)

112,786. The Eastville Engineering and Rock Drill Company, Limited, and W. Levermore, Fishponds, Bristol. Pneumatic Percussive Tools. (3 *Figs.*) July 8, 1916.—This invention relates to rock-hammer drills of the kind operated by compressed air and provided with a resiliently-mounted handle having a plurality of recesses engaged by corresponding projections on the tool and adapted to absorb or nullify the vibrations or concussions set up by the percussive action. According to the invention, the aforesaid plurality of recesses are adapted to receive metallic springs and are connected with corresponding lugs or projections on the tool by pin and slot connections, the said springs serving to take up or dampen



the vibrations that would be otherwise transmitted to the handle, as is well understood in connection with other forms of resilient handles. *a* denotes the handle and *b* the part of the tool to which the handle is attached. The handle is provided with portions *c* having recesses *d* formed therein for the reception of the projections *e* on the part *b* of the tool. Arranged within the recesses so as to be interposed between the handle and the projections are springs *f* which take up or dampen the vibrations which would be otherwise transmitted to the handle. The projections are provided with the slots *g* adapted to receive the transverse pins *h*, which serve to connect the handle to the projections whilst allowing for the relative movement set up by the vibrations of the tool as aforesaid. (*Sealed.*)

112,787. The Eastville Engineering and Rock Drill Company, Limited, and W. Levermore, Fishponds, Bristol. Pneumatic Percussive Tools. (3 *Figs.*) July 8, 1916.—This invention relates to rock-hammer drills of the kind adapted to be operated by compressed air and provided with a detachable drill or tool retaining chuck having a lateral slot or opening whereby the chuck can be removed without requiring to pass it over the full length of the tool, the chief object being to provide a drill or tool retaining chuck of this character which can be removed in a more expeditious manner than heretofore. According to the invention, the chuck consists of a sleeve-like member provided with the aforesaid lateral slot or opening and adapted to be detachably connected to the machine by a bayonet slot and pin arrangement. Two bayonet slots may be provided in the said member for engagement with corresponding lateral pins or projections on the machine. *a* denotes the sleeve-



like member and *b* (Fig. 3) the lateral slot or opening provided therein, whereby the sleeve can be passed laterally over the shank of the drill or tool (not shown). *c* denotes the bayonet slots and *d* the pins or projections with which the slots are adapted to engage, the pins or projections being provided on a part *e* of the machine. *f* denotes a spring for maintaining the sleeve in position against the pins or projections *d*. With this arrangement, when the drill is in position and the sleeve *a* is applied laterally to the drill and turned angularly into the position indicated in Figs. 1 and 2 so as to cause it to become locked by the co-action of the projections *d* and bayonet slots *c*, the drill becomes secured in position. When requiring to remove the sleeve *a* it is turned angularly in the reverse direction to disengage it from the projections *d*, whereupon the sleeve occupies such a position that the laterally-disposed slot *b* permits of its being instantaneously removed laterally without requiring to disturb either the drill or other parts of the machine. (*Sealed.*)

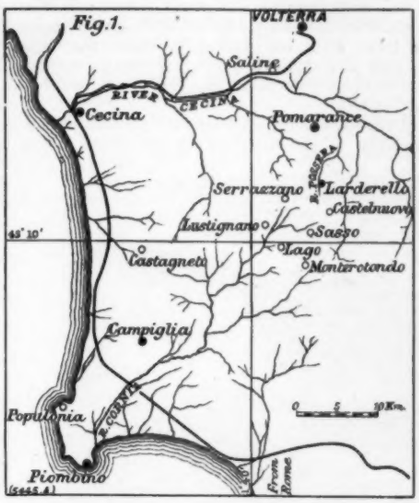
AMERICAN SHIPBUILDING ACTIVITY.—Keen rivalry has started between the Pacific and Atlantic Coast shipyards to establish during the summer a new record for the construction of an 8,000-ton steel cargo vessel. The record is now held by the Western Coast which launched a hull within 64 days after the keel was laid. An Atlantic shipyard has set out to beat this record, working double shifts on the ship, the keel of which was laid on Friday, the 12th inst. With favourable weather conditions the company hopes to cut down the time to less than 60 days. The Western firm has announced that they have made plans to turn out the next hull in their yards in 53 days. The Shipping War Industries Board is bending every effort to expedite the delivery of supplies to the shipyards, so that no delays may be attributed to the lack of supplies. The Shipping Board is planning to construct permanent quarters with 500,000 sq. ft. of floor space at a cost approximately of 5,000,000 dols. This is due to the growth of the organisation, which now occupies offices in 24 separate buildings.

THE LARDERELLO NATURAL STEAM POWER PLANT.

By UGO FUNAIOLI, *Director of the Electrical Department of the Società Boracifera di Larderello.*

IN the Province of Pisa, in Tuscany, not far from the ancient city of Volterra, renowned for its Etruscan memories, are to be found several natural steam springs, evidently due to latent volcanic activity. These springs have been known for some centuries, but they were only regarded as a natural curiosity, and were the objects of superstitious fear of the surrounding peasantry, till the year 1790, when a chemist of the Tuscan Court, Hoefer by name, and Paolo Mascagni, a professor of the University of Pisa, ascertained the presence of boric acid in the waters contained in one of these springs. The result of this important discovery was the birth of the well-known boracic works currently described in all treatises of chemistry and of geology.

The first important plant for the extraction of boric acid from the natural steam springs, was inaugurated in 1818 by the firm of Larderel, near the small hamlet of Montecerboli, and the new village which was then built in the immediate neighbourhood of the springs was called, after its founder, Larderello. The steam springs are found in eight localities, distributed in an area of about 100 sq. km., and in each of these localities there are boracic



found in quantities varying according to the nature of the locality.

The process for the extraction of the boric acid is extremely simple. The waters containing it in very small quantities (about 2 to 3 per 1,000) are conveyed, by means of special piping, to evaporating tanks or planes, called Caldaie Adriane, consisting of a series of very shallow basins lined with lead to prevent corrosion, due to sulphuric acid formed by the oxydation of SH_2. These basins are disposed on a slightly inclined plane, so that the water may pass from one to the other. The whole series is heated by means of natural steam passing in a flue under the basins.

The percentage of boric acid is thus brought to about 8 per cent., by concentration. By cooling the ultimate result of the solution, crystals of crude boric acid are obtained, which in many cases contain as much as 99 per cent. of pure boric acid. A special plant is in use for refining this acid, which can be reduced to powder, crystals, or paillettes. Borax is manufactured at Larderello by reaction between boric acid and carbonate of soda.

Another branch of the chemical works is represented by the process of manufacturing carbonate of ammonium synthetically, with ammonia obtained from the residue waters and carbonic acid separated from the natural steam. The chemical department is under the supervision of an expert doctor in chemistry, with a complete laboratory for all analyses and experiments. Since the beginning of the industry, it has been found necessary to obtain greater quantities of steam, and borings have therefore been made in the soil round the natural springs.

It may prove interesting to give an idea of the process actually followed for making these bores, the method followed differing from that in use for boring artesian wells, &c. The tools used are heavy steel chisels, which are attached to a rigid system of iron rods. The whole system is lifted by means of an electric winch, and when released the fall causes the chisel to penetrate into the soil. About 19 to 20 strokes per minute can be obtained in this fashion, and the rods are periodically turned through a certain angle so as to change the orientation of the blows. Of course, the rate of penetration differs according to the nature of the soil, which varies according to place and depth. The rubbish is removed from the hole by means of special implements.

Steam and water are found generally at a depth of 20 m., and even less, and the work from that point proceeds with increasing difficulty, requiring a specially-trained body of workmen. The holes are of various sizes; formerly they were not larger than 20 cm. (8 in.), but gradually the diameters have been increased to 40 cm., and experiments are being made to arrive at still larger diameters, in order to augment the output of steam. It is, of course, necessary to line the holes with tubing so as to prevent the crumbling down of their sides; and this is done by means of iron tubes welded together with oxy-hydrogen flame. The oxygen and hydrogen necessary for these operations are locally produced by the electrolysis of water.

When it is judged by signs known to the practised eye of the foreman, that the hole has reached sufficient depth, a curious and characteristic operation locally termed "sfulminazione" (explosion) is sometimes performed, in order to clear the interior of the hole from all remaining debris and of the water which balances the pressure of the steam.

This operation is effected by introducing into the hole a sort of rough piston, which is subsequently withdrawn as rapidly as possible by means of the electric winch. If all necessary conditions are fulfilled this provokes a small volcanic eruption; the hole emitting mud, stones and boiling water, which are projected with the greatest violence and noise to a considerable distance, sometimes smashing the wooden structure erected over the hole and covering the roofs of the surrounding buildings with mud and stones. This eruption lasts for some minutes, and is followed by the steady and continuous emission of dry steam, escaping with a characteristic hissing noise.

The depths of the steam wells range from 60 m. to 120 m.; in some instances a depth of 150 m. has been attained before provoking the explosion. The pressure of the steam at the point of its delivery depends upon the diameter of the tubes through which it is brought up, and also varies from one locality to another. The highest pressure, in Larderello, measured with closed valves over the *soffione* and with no efflux of steam, is about 3 atm. effective. This pressure decreases with the increase of steam output, and the mean pressure with maximum output is about 1 atm. effective. Accurate observations with recording pressure gauges continued for several months, have proved that, for a given opening of the stop valves the pressure of efflux is constant. The output varies in the "soffioni" at Larderello from 3,000 kg. of steam per hour, to 14,000 kg. The temperature of the steam measured at the top of the hole during efflux, amounts to 180 deg. C., as the steam is superheated by friction against the tubes lining the hole.

As to the origin of this steam, very little is known. Besides Larderello, other spots situated at distances ranging from a minimum of 3.5 km. to a maximum of about 12 km. from Larderello, present similar phenomena. At each of these spots there are works for the extraction of boric acid, the refining processes being all carried out at Larderello. The other works are at Castelnuovo, Sasso, Monterotondo, Lago, Lustignano, Sarrazzano and Travale.

The small map, Fig. 1, already referred to, of the region adjoining Larderello, shows that these various sites are situated in such a manner as to form a roughly elliptic figure with the exception of

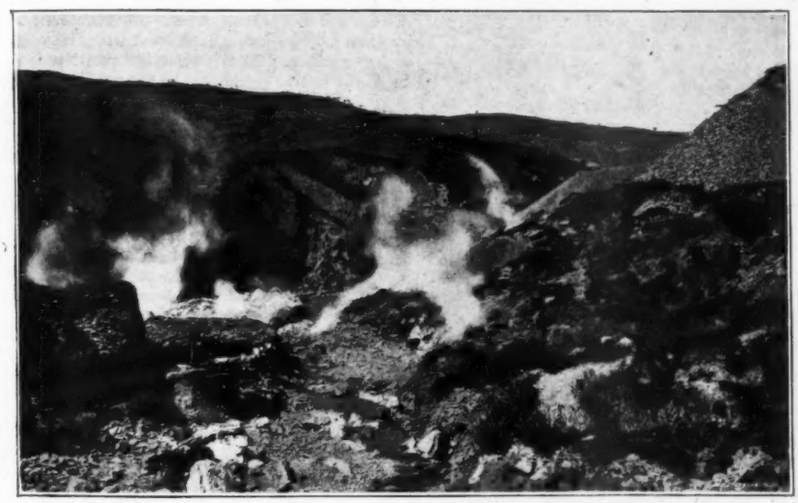


FIG. 2. NATURAL "SOFFIONI" IN THE BED OF THE TORRENT POSERA, AT LARDERELLO.

works. The various firms which exercised this industry have been incorporated in the present Società Boracifera di Larderello—a limited company. A small map of the region adjoining Larderello is given in Fig. 1, annexed.

In the natural condition, the steam finds its way through crevices in the soil, and sometimes issues at the bottom of small craters filled with water, which is kept at boiling-point by the steam, but more often in jets of steam or boiling water direct from the earth. These small craters are termed locally "lagoni," while the springs which give only steam are called "soffioni." Illustrations showing the character of these discharges are given in Figs. 2 to 4, on the present and following pages.

Besides steam, these springs emit a certain percentage of gases, chiefly CO_2, N and SH_2. There is also a certain quantity of helium, together with traces of other rare gases. It is not yet ascertained under what form boron is conveyed by the steam, it is however found as boric acid (H_3BO_3) in the waters resulting from the condensation of this steam. As to the presence of boric acid in the steam, more than one hypothesis has been advanced. The most likely one seems that proposed by Perrone, who supposes boric acid to be the result of the dissociation of tourmalines contained in porphyritic granite due to volcanic eruptions. Ammonia (NH_3) is also

Travale, which lies more to the east towards Siena. It will also be noted that the various works are all situated between the valleys of the rivers Cecina and Cornia, and near the foot of the hills dividing one valley from another; though these hills do not appear in the map. The geological nature of the soil does not seem to have a special determining influence on the actual production of the steam notwithstanding that it varies from one place to another, though it has undoubtedly an influence on the composition of the steam. The whole region where these volcanic manifestations as the fact that the continued boring of new steam wells shows a steady increase in the total quantity of steam emitted. Thus at Larderello, more than 70,000 kg. of steam are emitted per hour, solely by the wells used for the power station; and at Lago, after obtaining about 25,000 kg. of steam per hour, from one well only, about the same quantity was obtained from a subsequent perforation, without influencing materially the output of the first well.

At the same time, accurate measurements of the quantities of gas contained in the steam in the

FIG. 3. VIEW SHOWING "LAGONI."

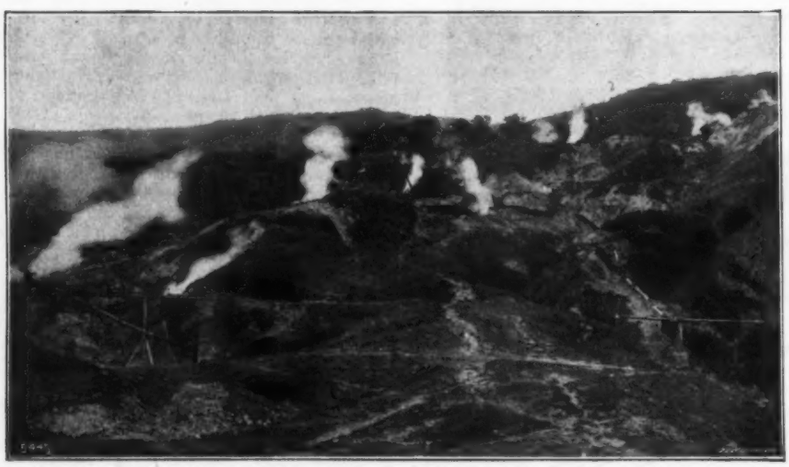


FIG. 4. VIEW OF THE VOLCANIC ZONE BETWEEN SASSO AND MONTE ROTONDO.

take place, belongs to the metalliferous range of hills of Tuscany, where iron and copper pyrites are to be found in abundance.

Important mines of these minerals are situated near Massa, not far from the most southern boracic works of Monterotondo, Lago and Travale. It is also a noticeable feature that the volcanic manifestations appear in several cases on the opposite sides of the same hill; such is the case at Larderello and Castelnuovo, at Sasso and Monterotondo. Between the two latter spots a narrow strip of land running across the hill over the summit and joining the two localities, is practically all volcanic ground. A theory was formulated some years ago on the migration of the "soffioni," *i.e.*, on a supposed tendency of these to change place, remounting the opposite slopes of the hill, but later observations have proved this to be erroneous.

Suppositions have also been made as to the common origin of all these "soffioni," and much can be said to support these theories, more especially various localities, seem to have given some rather interesting results, there being a marked difference in this respect between Monterotondo and Sasso, which, as stated above, form part of the same volcanic zone. This can be accounted for by the difference in the nature of the surface strata. The soil immediately surrounding the "soffioni" is generally completely arid, and often dangerous to walk upon. Several peculiar minerals are found near the Lagoni, *i.e.*, Larderellite (borate of ammonium) and Sassolino (orthoboric acid). Sulphur and hydrate of iron are also plentiful.

(To be continued.)

HARBOUR EXTENSION AT HAPARANDA.—It is proposed to extend the harbour accommodation at Haparanda, which place has become one of great importance for transit during the war, by constructing an outer harbour at Nikkola, at an outlay of some 3,000,000 kroner. This outer harbour and the Kalix Harbour may be combined in such a manner, that the connection with Haparanda is effected by means of a railway.

THE IRON AND STEEL INSTITUTE.

(Continued from page 496.)

We now deal with the further proceedings at the meeting of the Iron and Steel Institute held on Thursday, the 2nd inst.

On introducing the new president, Sir William Beardmore said that before he vacated the chair he would like to announce that the rules under which new members were elected were suspended in order to elect immediately as members Mr. Schneider's two sons, Mr. Jean Schneider, lieutenant in the French Flying Corps, Croix de Guerre, and Mr. Charles Schneider, lieutenant in the French Artillery. The announcement was received with acclamation. Mr. Schneider said he greatly appreciated the honour which had been conferred upon him and felt sure that our two countries would continue to stand together to the end. He very greatly appreciated the sympathy which had been extended to him at the loss in action of his eldest son; he had intended to ask that he, also, should become a member of the Institute.

In presenting the Bessemer medal for 1918 to Sir William Beardmore, Mr. Schneider said that all the members were fully aware of Sir William's merit, scientific and practical knowledge. He had started the manufacture of armour plates by his own process and had put down new works for naval enterprises, which works had developed to such an extent that they were now of the first magnitude. Sir William had also been one of the first industrialists to introduce female labour on munition work on a large scale and to deal with the welfare of his workers. As regarded his position in the Institute, he was elected to the Council in 1892, was elected a vice-president in 1906 and honorary treasurer in 1913. It would be remembered that at the autumn meeting held in Glasgow in 1901 he most cordially received the members. Mr. Schneider concluded by stating that Sir William had the best wishes of the Institute for further success and continued prosperity.

Sir William Beardmore, in the course of a brief acknowledgment, said the honour which had been conferred upon him, the highest reward in the gift of the Institute, was one which he much appreciated and would always value.

Mr. Schneider then delivered his presidential address; this we reproduced in full on page 497 *ante*.

Sir Robert Hadfield, Bart., as the senior past-president present at the meeting, in moving a vote of thanks to the president for his address, said this latter was one which each member could take home and study with advantage. A presidential address was never discussed, but he felt sure that if a discussion did take place in the present instance there would be no word of dissent from the views expressed by their new president. In an historical occasion like the present one, he (Sir Robert) was glad to see a French gentleman in the chair; the Tricolour and the Union Jack were floating side by side. He had visited Creusot works in the past and had been cordially received; he wished those works and the new works which Mr. Schneider had put down in different parts of France since the war broke out, continued prosperity. Not only had the nomination of the new president been received with acclamation by the Iron and Steel Institute, but the Institution of Civil Engineers had deputed him (Sir Robert) to express their great pleasure at his appointment, as also did the Institution of Automobile Engineers, the Faraday Society, the Institution of Mechanical Engineers, and other bodies, who all wished him every success in his office.

The vote was carried unanimously.

REPORT OF COMMITTEE NO. 2, FOR BLAST-FURNACE PRACTICE.

The first paper taken at the meeting on Thursday morning was the Report of Committee No. 2, for Blast-Furnace Practice. It was read in abstract by Colonel W. Hawdon, the chairman of the committee. We reproduced it in full on page 480 *ante*, and need not refer to it specially here.

The discussion was opened by Mr. J. H. Harrison who stated that as a member of the committee he had nothing to add to the report; he fully endorsed

it. The committee had had evidence that the information gathered would prove useful to blast-furnace men in this country. A large amount of information had been gathered, from which a certain amount of weeding-out had to be made. It might be that some points had not been touched upon; the committee were not able to deal with every point, they had included in the report those facts which they thought would be of special interest to the meeting, and he (Mr. Harrison) asked that the report should be discussed in the shape in which it had been put forward.

Mr. Cosmo Johns thought that there were one or two questions which would be of special interest to the members of other committees, for instance, to Committee No. 1, which dealt with ores, fuel and refractories. All seemed to be well in blast-furnace practice from the point of view of refractories, in the use of high fire-resisting quality of refractories for the lower part of the furnace and hard brick for the upper part. The use of these qualities in their respective parts was the right one. He would put in writing his views on the special problems to be faced in this respect. The next most important point was that which had reference to the ores, and blast furnace men would like more information on the structure and chemical composition of the ores. There would occur continual changes in the character of the ores used, and he was afraid the changes would be for the worse as time went on. It would be desirable to put on record the structure and chemical composition of the ores of the present day, for use in future days. In these respects, he suggested that there appeared to be room for a greater co-ordination of the work carried out by the various committees.

Mr. T. B. Rogerson, who followed, in the course of his remarks stated that the Scotch limestone was not so good as it was in other parts of Britain. The old splint coal of Scotland was no longer available; it used to make a high grade pig-iron. Now they had friable coal which would not carry the burden, and there was difficulty in getting the former coal consumption and also the former output of iron. Scotch coke was poor, and what they had was almost all used for foundry work. They were using gas coke leaving as much as from 12 per cent. to 16 per cent. of ash. He also believed that the fuel in the Middlesbrough district was also now not so good as that of, say, twenty or thirty years ago.

Sir John S. Randles expressed the hope that from the replies the committee had received something would emerge of value to the British blast-furnace men. In the present case, the lesson we were now learning was pretty much the lesson the present war was teaching us in other branches. There was a great need for accuracy and precision generally, and the life of civilisation was dependent upon minute accuracy in many instances. For example, the weight of a shell had to be perfectly accurate, for the least deviation might change all the conditions of a fight. In regard to blast-furnace practice, they had been endeavouring to find out how best to proceed, but this should not result in imitation to too great an extent, and the work of the blast-furnace was not one to study year by year, but rather day by day. Many blast-furnace men had always the resource to say that either the coke or the ironstone had gone wrong when unsatisfactory conditions supervened, but it should be remembered that the blast furnace was a piece of machinery which required humouring. Further, the replies received showed the material used to be of a very great variety, which made it evident that each blast furnace owner had to be his own student, not only from day to day, but even from hour to hour. A blast-furnace plant was a most complicated one and too much should not be expected at one part of the country from the information derived from another part. Reliance had to be put upon one's own personal knowledge, but, notwithstanding, the work of the committee would be found useful in that it induced each one to study his own plant thoroughly and to get from it the best possible results.

Professor W. A. Bone, referring to Mr. Cosmo John's remarks, urged that the council should consider amalgamating the work of Committee No. 1, on ore, fuel and refractories, with that of Committee No. 2, on blast furnace practice. It was strange that the question of fuel should be diverted from the latter committee.

Mr. W. H. Hewlett also urged for co-ordination in the work of the two committees.

Mr. J. H. Harrison, speaking again on the report, said that it opened the door to other papers of a practical nature. He instanced the question of breaking the ore; at two works the large ore was broken to about 5 in. cubes, the large and small being tipped in separate bins; by breaking the ore to the extent of 10 per cent. of the total burden, the load of the burden was increased by 6 per cent. This was not usual in this country, and by breaking the lumps to 5-in. cubes, the small being kept out of the calcining kilns, there was a better calcination and a better output from the blast furnace. In regard to the size of the bell, the conclusion generally arrived at showed that the area of the bell should be about half the area of the furnace throat at the stock line. This was the conclusion reached in reply to question No. 10.

Mr. W. J. Foster stated that his firm had done their part in replying to the questions which had been asked, but he had to confess that these questions were perhaps too elementary, and did not interest the scientific blast furnace man to the extent which might have obtained. He, the speaker, referred in his remarks to thin linings and thought that Colonel Hawson was looking forward to a reduction in the cost of the lining and to providing a much better lining. At Darlaston, he (the speaker) was putting down a blast furnace, capable of making, with a 50 per cent. mixture, 700 tons of pig iron per day, with a blast of 40,000 cub. ft. of free air, heated to a temperature of about 1,000 deg. C. It would have three distinct linings, the hearth and bosh of carbon, from the bosh and for about 50 ft. there would be very hard brick, and on the top of that there would be a metal lining. If Dr. Stead's prediction in his paper on blast furnace bears was right, there would be four distinct linings; in other words, he was inclined to think that a mixture of magnesite brick with carbon might be used in parts of the furnace. But he would not go further in the matter as he was going to give a lecture shortly at Birmingham on blast furnace practice.

On the motion of the president, Committee No. 2 were awarded a hearty vote of thanks for their communication and Colonel Hawdon was invited to reply in writing to the discussion.

The Jurassic Ironstones of the United Kingdom Economically Considered.

The next paper taken was the one bearing the above title, by Mr. F. H. Hatch, who read it in abstract. We commence its publication on page 514. It deals extensively with the subject and is most satisfactory in that it shows the large amount of ironstone still available in this country.

The discussion was opened by Professor H. Louis, who thought the author deserved the best thanks of the Institute for the trouble he had taken in collecting such a large amount of valuable information on the mineral resources of the United Kingdom. He differed from the author in one point. The latter had stated that in Northampton there were two types, a green, unaltered lower portion in which the iron was in the ferrous state, partly as carbonate and partly as silicate, low in iron and comparatively high in lime, and a red, upper portion in which the leaching out of the lime had raised the percentage of the other constituents; this was comparatively high in iron and silica. He (the speaker) had carried out experiments with the green portion and dissented from that statement, that portion was richer. Analyses had shown that there was 50 per cent. of iron in the calcined stone of the green portion, and it was more largely a carbonate than a silicate. On one occasion he wanted to get samples from a shaft sunk in the green portion and notwithstanding the ventilation, he could not stay long enough down the shaft for collecting the samples without going to the ventilation pipes to get a breath of fresh air. Gas was developed to a very large extent owing to the very rapid oxidation of the ores. He found the green carbonate ores richer than the brown ores, and he had a very great impression that the leaching out which took place in the red, upper portion was not confined to the lime, but that a large proportion of the iron was leached out also.

Mr. H. K. Scott, referring to the author's figures showing that the yield per man working underground was much less than that per man in open workings, said that these did not hold out a great prospect of doing better by underground mining than by quarrying; he thought that some large figures could be adduced for underground working in Northampton. As to the quarry owners not sufficiently realising, as stated by the author, the importance of maintaining a uniform mechanical condition in the ironstone, in order to secure a regular distribution of the charge in the blast furnace, he believed that too much emphasis could not be laid upon the point. The tendency was to take more from the lower portion of the strata, whilst it was desirable that more should be left there at the present time for future workers to deal with. With regard to the transport of the ore to the furnaces and the lack of storage facilities at many furnaces touched upon by the author, he (the speaker) would be pleased if ironmasters would bear all these points in mind. In many instances, there were no satisfactory arrangements for bunkering at the furnaces; there was a very detrimental lack of synchronism between the transport and delivery of the ores, and the working of the blast furnace. If these ores were to be used on a larger scale than formerly, adequate bunkering was necessary. As to calcination of the ironstone at the quarries, he (the speaker) was not sure that there was a great advantage in that; some ore which had been calcined at the quarry showed 13 per cent. of moisture on reaching the blast furnace, it having got soaked with rain on the way there. Besides, calcination in an open plant led to an unusual amount of small. With reference to the restoration of land to the farmer, he thought that partial restoration only should be done and more mining timber grown. Mechanical appliances should be introduced when they could do the work as cheaply as it was done by hand; any getting of the cover by hand in the Midlands could hardly be defended, labour being so scarce.

Mr. Lloyd did not agree with Professor Louis in his statement given above, but with the author; the lower portion was higher in lime and lower in iron than the upper portion.

Sir William H. Ellis, reverting to the transport question and the lack of storage facilities, said that the author's important remark applied to the ironstone and it wanted extension so as to cover the coke also, for there were instances in which no facilities were available for dealing with the coke. In this, a great risk was run, for if there occurred a stoppage in railway facilities there might follow a stoppage in the working of blast furnaces. There should be made provision for storing coke in bunkers instead of leaving it long in the railway wagons as was now frequently the case.

Mr. J. H. Harrison thought that Sir William Ellis was under a misapprehension if he thought that the cost of coke bunkers came in for consideration. The fact was that some coke would not bear putting in bunkers, because of the amount of small that was produced thereby. In some places in South Yorkshire although coke bunkers were available they were never used, because they led to much more small than when the coke was left standing in the railway trucks.

Mr. F. H. Hatch, in replying briefly to the discussion, said he agreed with Professor Louis that the green ore was probably more largely a carbonate than a silicate, but as to the green ore being richer than the high grade oxidised ore, Professor Louis' opinion seemed different from that generally entertained. In regard to the output per man working underground, Mr. Scott had perhaps more in view the future, whilst he (the author) had given the facts as they were. He was satisfied that underground working was not more costly than quarrying.

The author, on the motion of the chairman,

received the thanks of the meeting for his contribution.

FUEL ECONOMY IN BLAST FURNACES.

The first paper taken at the afternoon meeting on Thursday, the 2nd inst., was one on "Fuel Economy in Blast Furnaces," by Mr. T. C. Hutchinson. In the latter's absence, it was read in abstract by Mr. A. Hutchinson. We reproduced it in full on page 483 *ante*. In his opening remarks, Mr. A. Hutchinson stated that the fact that there were two other papers on the programme for the afternoon sitting dealing with blast furnaces showed that the work of Committee No. 2 had not been in vain. It had resulted in some papers of a practical nature being put forward which would lead to an exchange of opinions having for its result an improvement in blast furnace practice.

THE IMPORTANCE OF COKE HARDNESS.

The paper by Mr. G. D. Cochrane having the above title was next read in abstract by the author. We reproduce it on page 529. Mr. Cochrane added a few remarks to the following effect. The average output of three Ormesby furnaces in 1910 was 2,749 tons, and the coke hardness was 76.4 per cent. The corresponding figures for the following years were as follows; 1911, 2,687 tons and 75.62 per cent.; 1912, 2,649 tons and 74.96 per cent.; 1913, 2,596 tons and 73.97 per cent.; 1914, 2,623 tons and 74.69 per cent.; and 1915, 2,347 tons and 72.75 per cent. These figures show the relation between coke hardness and output of pig iron. During these years, the average blast pressure was 6.5 lbs. If the coke had a low percentage of ash, about 6 per cent., there was far less chance of the coke being broken up by the cleavage radiating from shale existing in coke with a high ash content. When the coal was properly ground and especially the shale it might contain, although there would be an increased coke consumption due to the greater ash content, the increased consumption would not be excessive. It was spongy coke which gave high coke consumption and unsatisfactory furnace driving.

COPPER TUYERES FOR BLAST FURNACES.

The third paper on "Copper Tuyeres for Blast Furnaces," by Mr. A. K. Reese, was read in abstract by the Secretary. We reproduce Mr. Reese's paper on page 517. The three papers were taken together for discussion.

This was opened by Dr. Stead, who said that his own paper on "Blast Furnaces Bears" would not be called up for reading; it would be taken as read, He pleaded guilty in studying bears to be on a sportsman's business, since bears were not opened up every day. There was a common point in both Mr. Hutchinson's and Mr. Cochrane's paper, namely, the question of the distribution of the material in the furnace. The former had shown that by altering the shape of the bell he obtained better results, and he saved in coke. By throwing the small outwards he saved the lining, but incidentally he reduced the capacity of his furnace. He asked Mr. Hutchinson whether, if he could by any means secure that the whole of the material be properly and equally distributed over the whole surface, he would not be able to save still more coke. Mr. Cochrane had laid stress upon the quality of coke used, whilst Mr. Hutchinson had insisted upon the proper distribution of the material in the furnace. It was common knowledge that the fine coke was sifted off before the coke came to the furnace, but in putting the coke into the furnace small was produced. The small got into the interstices of the material and the gases did not flow up regularly through the whole column. Mr. Cochrane had given him (the speaker) three samples of coke, a soft, a medium soft, and a hard specimen, upon which he had experimented. He had found that the softest coke was physically harder than the medium one, or practically so. The hardest coke of all did not lose an atom; it was of the same weight as before the experiment. Next in order came the porous coke, which was a cellular mass of 0.6 specific gravity. The soft coke broke down under a much less weight; carbonic acid did not readily attack it and in this respect the medium and the hard behaved in the same way. When charcoal, which was relatively a soft material, was used in one furnace, and coke in another, both using the same kind of ironstone, only $\frac{2}{3}$ the quantity of charcoal was used as compared with the coke. He thought therefore that the whole question needed reconsideration.

Colonel W. Hawdon said that although the Committee No. 2 on blast-furnace practice had not produced anything very exciting it had at least brought forth further papers. Others had been promised, on the cleaning of gases and also on dry air. He thought the life of the furnace referred to by Mr. Hutchinson was due to the putting of the small against the lumps, the result being a protection for the lining. What he (the speaker) aimed at was a better distribution in the furnace. In regard to the bells, he had obtained better results sometimes with large bells and sometimes with small ones; it depended upon the size of the furnace and upon the stock line. As to permeation by the gases, if the larger material occurred in the middle of the furnace, only the middle part would be working and that meant a reduction in the size of the furnace. Mr. Hutchinson, with reference to sulphur, had stated that the low sulphur content had proved that the sulphur band brought with the ironstone from the mines could be mechanically removed at the cleaning belt. That was so to a large extent, but he (the speaker) had found that in some parts of Cleveland the ironstone was permeated with more sulphur than in others. Dealing with Mr. Cochrane's paper, Colonel Hawdon said that everybody knew that hard coke was the best for the furnace. There was a great difference between the yield of good and badly designed coke ovens, and if a coke oven did not give a very good heat, a good coke could not be obtained. He might probably soon have a blast furnace bear when he could immediately inform Dr. Stead.

Mr. E. Adamson stated that in his experience both with cupola and blast-furnace coke, the harder quality always gave the best results, and he was surprised that there should be a difference of opinion in the matter.

Professor W. A. Bone, speaking on Mr. Cochrane's paper, pointed out that one important aspect of the question, namely, what causes the hardness of coke, had not been dealt with. It had been found in practice that hard coke gave the best results in the blast furnace, and for this purpose coke could be graded, and the most advantageous quality selected for use. But this left untouched the question as to what caused the hardness of coke and how it might be increased. At least two factors were concerned in determining the hardness of coke, the one dependent upon the nature of the coal itself, *i.e.*, upon its coking properties, and the other upon the precise conditions under which it was carbonised. With regard to the first factor, recent advances in our chemical knowledge of coal had shown that in all probability the coking properties of a given variety of it were connected with, or caused by, the presence of certain constituents which could be removed by extraction with suitable organic solvents. For when even the best coking coals were so extracted the residual material, which constituted by far the larger portion of the coal substance, was quite devoid of coking properties. Also, the coking properties of a coal were diminished, and finally entirely destroyed, by atmospheric oxidation at comparatively low temperatures, such as, for instance, in the weathering of coal. It should always be remembered that on carbonising coal in a coke oven, the charge was never suddenly heated up to the maximum coking temperature, but passed gradually through every degree of heat up to that point. Hence the coal first of all underwent chemical decomposition at comparatively low temperatures yielding intermediate volatile and gaseous products, which in their turn, at higher temperatures in the oven, underwent secondary decompositions. He was inclined to think that in all probability it was during the course of such secondary decomposition that what was usually meant by the "hardness" of coke, from a blast-furnace standpoint, arose. Professor Bone then pointed out that from a chemical standpoint, the coal substance contained three distinct types of constituents, namely (1) cellulosic, (2) resinic, and (3) nitrogenous, which had been derived from the cellulose, resins, and proteids, respectively, contained in the original vegetable *débris*, from which the coalfields were formed. The greater part of coal was originally derived from lignified cellulose, $n(C_6H_{10}O_5)$, which, according to the most recent researches, consisted of closed ring systems each containing six carbon atoms. And when coal was distilled at comparatively low temperatures, oils were expelled, largely consisting of hydrocarbons of the naphthene series C_nN_{2n}. Such hydrocarbons contained a "hexamethylene" ring of six carbon atoms, with side chains attached. As the distillation temperature rose, these side chains were split off, yielding methane and perhaps also higher paraffin hydrocarbons. And at still higher temperatures, the "hexamethylene" ring systems gave rise to "benzenoid" hydrocarbons and hydrogen. It was probably during the decomposition and subsequent breaking down of these ring systems that what might be regarded as the "soft carbon," or the "carbonaceous basis" of coke was largely formed. At a later stage, and at higher temperatures, this "carbonaceous basis" became overlaid with a hard carbon formed by the decomposition of methane in contact with it, and he believed that this decomposition of methane was largely responsible for imparting the property of "hardness" to coke. In his own researches years ago upon the thermal decomposition of hydrocarbons, he had found that when methane was heated in a porcelain tube to temperatures of 900 deg. C. and upwards, it deposited on the walls of the tube a peculiar dense, hard form of carbon, with a highly metallic lustre, utterly unlike the soft black ("lamp black") carbon which was deposited by the decomposition of either acetylene or ethylene. Moreover, whilst at high temperatures methane never decomposed except in contact with a surface, the other hydrocarbons decomposed readily throughout their whole volume. He, therefore, suggested that it would be worth while to investigate the question experimentally, in the light of the hypothesis that coke was formed of a primary carbonaceous basis which was open in texture and comparatively soft in character overlaid by a hard metallic carbon produced by the high temperature decomposition of methane in contact with it. He would be glad to co-operate with anyone who had facilities for such an investigation.

Dr. Stead here remarked that it had never occurred to him for a moment to suggest the use of soft coke in blast furnaces.

Mr. D. Sillars stated with reference to Dr. Stead's comparison of a charcoal and a coke blast furnace that the fusibility of the slag and the temperature at which the charcoal furnace worked came in for consideration. He found Mr. Hutchinson's diagrams interesting, but they applied to models, and he would ask whether one could theorise from what was observed in a model and establish therefrom comparisons with what took place in a blast furnace. In regard to Mr. Cochrane's paper, he would ask what was meant when hardness of coke was referred to. Did it mean the quality which caused coke not to break when roughly handled? Or did it mean hardness which resisted solution with carbon dioxide? He had tried Mr. Cochrane's apparatus, but had not found it successful. The edges of the coke were broken and the corners knocked off, there was a reduction in size. It did not give a measure of the hardness, but of the resistance of edges and corners. He (the speaker) had tested hardness by using a weighted needle, and when this was dropped near a particle of ash in the coke, small cracks tended to radiate from that point and the larger the particle of ash the greater the tendency to those cracks. The distribution of the ash had no doubt a great deal to do with the hardness and the liability to breaking when the coke was dropped. Dealing with Mr. Reese's paper, he (the speaker) said the author would have contributed information if he had stated how his tuyeres were to be made. Tuyeres did not stand because they wore away by material running over them, it was because the metal of which they were made was, metallographically speaking, porous. Large crystals were formed, carbon dioxide penetrated between the crystals and rendered the whole of the copper

brittle. What was wanted was to put work on the copper, but unfortunately hammered tuyeres were not obtainable.

Mr. G. W. Hewson, who followed, said that the making of pig-iron was surrounded with many unsolved problems. We made steel according to specification, but this could not be applied to the making of pig-iron. But with the modern demands it became more and more necessary to turn out a uniform pig-iron, and he agreed with Mr. Cochrane that the most important factor was the mechanical condition of the coke, and that could only be controlled by the coke maker. The latter knowing the needs of the blast-furnace man would fulfil them. Mr. Cochrane had shown that better working did not mean increased blast pressure, but went with harder coke. He was glad to see Mr. Cochrane's description of his coke tester; it was an improvement upon one which he (Mr. Hewson) had described.

Mr. J. H. Harrison thought Mr. Hutchinson should be congratulated for having worked the blast furnace he referred to so successfully during twenty-two to twenty-five years without blowing out. With regard to the size of the bell and the proper distribution of the material in the furnace, the explanation was quite simple. In the first instance the bell was 13 ft. and the throat 23 ft. It was established at the discussion in the morning that there was a direct ratio of area of bell to throat of furnace of 1 to 2. Mr. Hutchinson increased the bell from 13 ft. diameter (one-third the area of throat) to 15 ft. 6 in. diameter (half the area of throat), and he came to almost the same decision that that was the right ratio. In other words, the furnace bell was too small at first; he put in a larger one, of the right ratio to throat and obtained better results. That was the right thing to do. Mr. Harrison then drew a sketch on the blackboard to explain how in that case the point of density was pushed outward, nearer to the side walls, which made the area within this ring of more dense material, material exactly the same as the area of the annular space between this ring and the side walls, and which was the means of bringing about the more uniform working of the furnace. The author's furnace was reduced in size at first because it was not active over the whole diameter of the charge, hence the material which formed on the side walls and saved the lining bricks. Mr. Harrison congratulated Mr. Cochrane upon his paper dealing with coke hardness and remarked that there was here a good opportunity for a skilful coke maker who would be able to make a hard coke from coal which was chemically not so good as his neighbour's. Its being made into a harder coke was of great value to blast furnace men.

Mr. J. S. Hollings stated that one factor had not been mentioned as to the life of the lining; he thought it was as important as the distribution of the material, and had reference to the size of the furnace. Mr. Hutchinson only gave the diameters of the furnace and one could not easily calculate therefrom the capacity. He (the speaker) thought the capacity could not be less than 25,000 cub. ft.; for its output, this was a large capacity. Some furnaces in the minette district of the Continent had an average of about 90 cub. ft. to 100 cub. ft. of capacity per ton of pig-iron per 24 hours. In the United States the capacity was about 60 cub. ft. per ton per 24 hours. The life of the lining in Mr. Hutchinson's case was probably due to the furnace being slowly driven for its size, and to its very small hearth diameter compared with its bosh and stock diameters. Mr. Hutchinson had called attention to the important point of the distribution of the material, and that was the factor which made for economical working. In one instance which came to the speaker's notice, the charges were previously mixed on the bell, and by lowering them in the form of a ring the output of the furnace was increased by over 50 per cent. coupled with a decrease in coke consumption. With reference to Mr. Cochrane's paper, he stated that he experimented with compression of the fuel before charging the coke ovens, with a view to render the coke harder; experience had shown him that, compared with coke obtained without compression of the coal, the burden of the furnace could be increased by 7½ per cent. if coke were used which had been obtained from compressed coal charges in the coke ovens. There was much in Professor Bone's th ory, and all coke makers had found that coke was harder when it came from some parts of the coke ovens when compared to that from other parts of the ovens.

At this point the meeting was adjourned until the following day, and on the members reassembling on Friday, the 3rd inst., a letter was read by the Secretary, received from the Institution of Metals, conveying the gratification with which that Institution had learned of Mr. Schneider's nomination as president of the Iron and Steel Institute, and acknowledging his great services to France and the Allies in the war.

The discussion of the three papers before the meeting was then resumed, when Mr. C. H. Ridsdale said there was no doubt that Mr. Cochrane in raising the question of coke hardness had rendered a valuable service to the Institute and to the blast furnace owners. There always was a tendency to buy coke 6d. or 1s. per ton cheaper; the coke was soft and the blast furnace man had many difficulties which he would not experience with a harder coke, and a hard coke had a great bearing upon blast furnace work. The question was summed up in the presence of dead small. He had ventured on former occasions to remove the dead small before charging, as the dead small acted upon the driving of the furnace; it disorganised the furnace. Further, the coke when obtained of a good make had also to be uniform. The small retarded the coke in the development of its full potential heat and made it longer to burn. The chemical loss had been referred to; there was something in that, but there was also a mechanical loss which occurred in the shape of dust. He (the speaker) had the occasion about eighteen years ago to make the balance sheets of coke equivalents right through and had found that in one instance 21 cwt. to 27 cwt. of coke was required per ton of pig-iron. He had always found moreover that the bulk of the heat was absorbed in the dead operation, that is to say, in the ordinary melting of the ore and in the provision of heat for transmission. The hearth was the most sensitive part, and only one-third of the potential heat in the coke was developed there. The altering of the quality of the coke had an effect upon the working of the furnace and upon the quality of the pig-iron. Every blast furnace man knew the sort of coke he wanted, and it was a simple matter for him to say whether any particular grade was suitable.

Professor H. Louis thought there had been a misuse of language with reference to hardness. Mr. Cochrane had said that hardness depended upon the physical quality, and the quality he referred to was resistance to abrasion. According to him, therefore, it would seem that pieces of india rubber tested in his machine would come out best. Mr. Stead interpreted hardness in a different sense; according to him it was resistance to chemical action. Professor Louis thought that trouble would arise if the word were used in an indescriminate fashion; it would lead to indifferent results in working. The term hardness should not be given several meanings. He asked why Mr. Reese confined his tuyeres to copper and brass, for he (the speaker) had found bronze tuyeres most successful. A bronze tuyere could be placed in a cast-iron cooling part; it was not necessary to make this of the expensive metal. He thought that aspect might have been touched upon.

Mr. Cochrane, in the course of his reply, thanked Dr. Stead for his experiments on the pieces of coke he (Mr. Cochrane) had sent him; he could not understand how it was that the hardness of the medium sample came our worse than the softest. He found out after that the sampler had mixed up the labels. All the experiments carried out by Bell showed that the soft coke lost more carbon than the harder. For many years at his plant, the breeze was taken out before putting the coke into the blast furnace; the coke was run on a screen and the breeze which fell apart was used for calcining the ironstone. With coke of average hardness, the breeze was about 6 per cent.; with soft coke it was as high as 9 per cent. Advantages were gained in taking that breeze out of the coke. Professor Bone had explained the generation of coke from the point of view of the scientist, and he (the speaker) agreed with his remarks. But although one should undertake scientific work, there were points of a practical nature which could be looked into at the present time, for example, the temperature of the coke ovens should be carefully watched. The lack of pyrometers which existed in a great many plants was really astonishing in these days. With regard to Professor Louis' observation on the misuse of terms, he (the speaker) agreed it was an error to use the term "hardness," but did not know what word to suggest. In the matter of compressing the coal, he (the speaker), had once obtained up to 80 per cent. hardness with stamped coal. Mr. Sillars had expressed the opinion that his (the speaker's) machine was not an accurate test for hardness; in reply to this, he would say that if his method were so absolutely casual, how was it he obtained the results he did, results which proved that the coke which was good under the test was most satisfactory also in the blast furnace. At Ormesby, he used a 15 ft. 6 in. bell. He then gave the working of several of his furnaces to show the life of the lining. His No. 2 furnace was in blast from 1876 to 1914, or 38 years, and produced 1,365,370 tons of pig-iron, which was a record. His No. 1 furnace was comparable to Mr. Hutchinson's No. 3 as to the date of blowing in, and both were still in blast; Mr. Hutchinson's had produced 769,000 tons to January, 1918, and his (the speaker's) 1,044,000 tons. His furnace was, however, much larger than Mr. Hutchinson's. The Report of Committee No. 2 had stated that a 28-ft. diameter bosh for Cleveland was thought to be correct and for this a 13-ft. diameter bell would be put in. He would like to have these figures explained for the larger bell of his furnaces gave a good distribution and the coke consumption was low. Mr. Sillars raised objections to the use of a model and to the comparison between action in the model and what took place in a blast furnace. He (the speaker) had used a model for many years for experimental purposes as to scaffolding among other matters, and from these experiments he had found that the great point was to get the pipe that formed well filled up with coke, so as to get the coke to burn the scaffolding out. If ore were not put in, but only coke, the scaffolding would be removed. From the model, he calculated the quantity of coke he would require and he obtained absolutely concurrent results in actual work. In concluding his remarks, he said he had found many copper tuyeres to fail owing to their having been cast nose downwards.

Mr. A. Hutchinson then briefly remarked that his father, Mr. T. C. Hutchinson, would read the discussion which had taken place with great interest, and would reply by a written contribution to the proceedings.

On the motion of the chairman, the authors of the three papers were awarded a cordial vote of thanks for their communications.

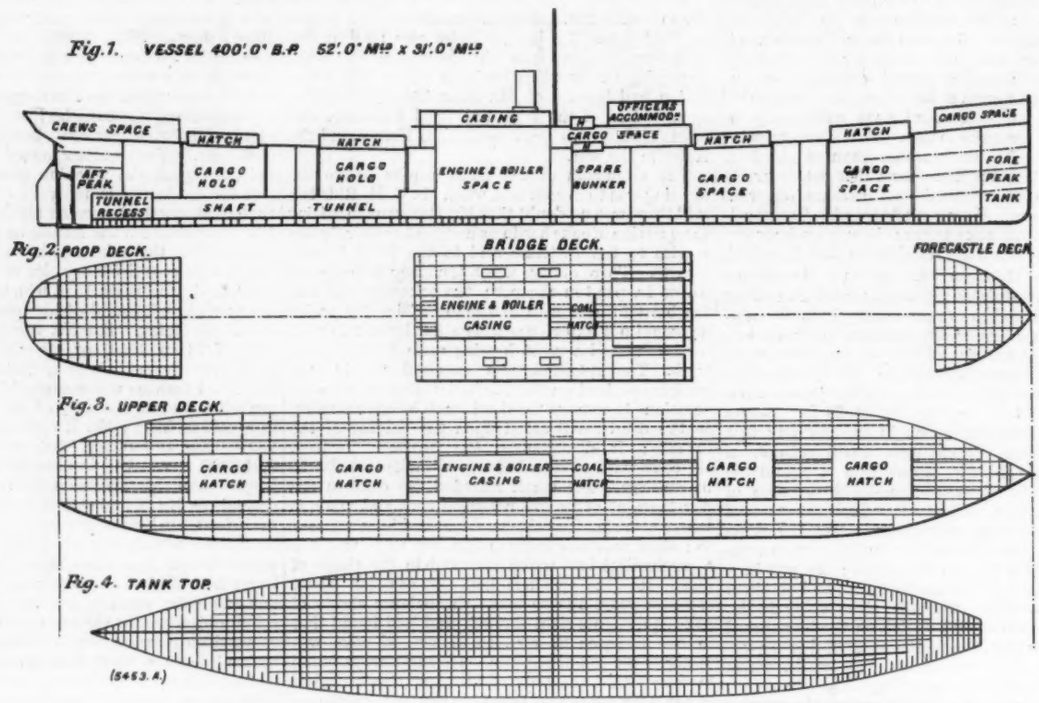
(To be continued.)

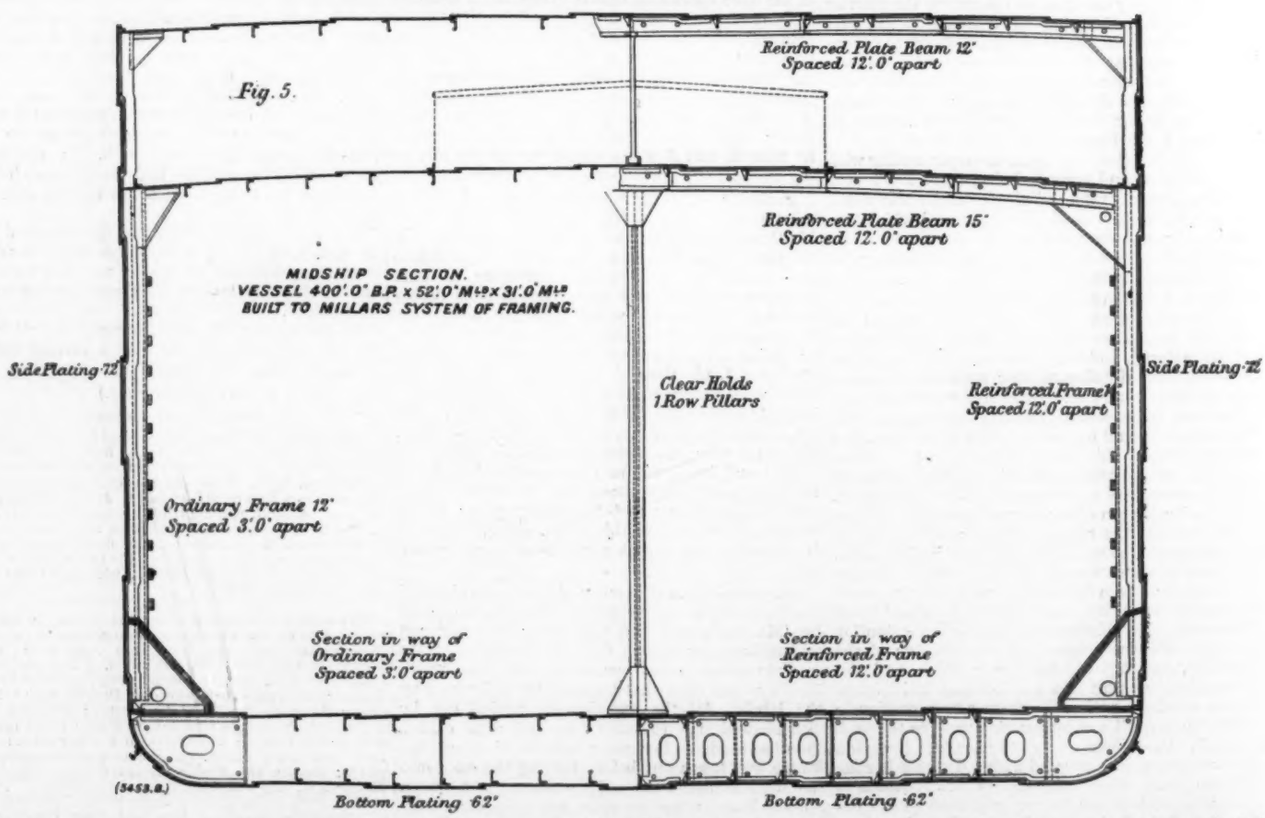
TESTING MANILA ROPE.—A method for testing manila rope, says *Machinery*, New York, has been developed by C. E. Swett, of the Arthur D. Little, Inc. Laboratories, Cambridge, Mass. This test has been adopted by the United States Bureau of Standards. It consists in freeing the rope from oil, soaking it for 20 seconds in a solution of bleaching powder acidulated with acetic acid, rinsing in water and then in alcohol, and finally exposing the fibres of the rope for a minute to the fumes of ammonia. Manila fibre turns russet brown, while all other rope fibres turn a cherry red.

ALUMINIUM.—Aluminium is the metal which is responsible for the entrance of France into the field of electrometallurgy, says *The Iron Age*, New York. Before the war, France led the world, with a productive capacity of 39·2 per cent. of the total, followed by the United States, with 25·8 per cent.; Canada, with 5·2 per cent.; Switzerland with 12·4 per cent.; Germany with 1·2 per cent.; Austria with 1·6 per cent.; Great Britain with 7·8 per cent.; Norway with 4·3 per cent.; and Italy with 2·5 per cent. Of the 10 French aluminium plants, nine in the Alps represented an aggregate of 12,000 h.p., the other is in southern France. From 1886 to 1896, Switzerland and not France led the world in aluminium capacity. One important reason why France attained a leading position was that at first and until recent years practically all the bauxite used for making aluminium came from France. The French bauxite is generally considered superior in quality to that from any other source. In spite of her great advantages, however, France, adds our contemporary has not retained the leading position.

THE MILLAR SYSTEM OF LONGITUDINAL AND TRANSVERSE SHIP FRAMING.

CONSTRUCTED BY THE GREENOCK AND GRANGEMOUTH DOCKYARD COMPANY, LIMITED, GREENOCK.





On the present and opposite pages we illustrate the Millar system of ship framing, which combines in the hull of a ship transverse framing and longitudinal decks and bottoms, a system applied already to six ships built or building by the Greenock and Grangemouth Dockyard Company, Ltd., at their works at Greenock and Grangemouth. The longitudinal system, as is well known, has been applied in many ships, and by many shipowners is preferred to the ordinary transverse system. But here the two systems are combined, with a view principally of giving the ship, as a girder, greater strength longitudinally against the stresses consequent on hogging and sagging, and great vertical stiffness against collision alongside wharves, piers, &c. Briefly, the double bottom of the ships, as well as the decks, are constructed with the main members running longitudinally, while the sides of the ship are constructed with vertical framing securely attached to the double bottom, either to the tank top or to the margin plate. The system so adopted by Mr. William Millar, the head of the dockyard company named, is a result of his

THE MILLAR SYSTEM OF LONGITUDINAL AND TRANSVERSE SHIP FRAMING.

CONSTRUCTED BY THE GREENOCK AND GRANGEMOUTH DOCKYARD COMPANY, LIMITED, GREENOCK.

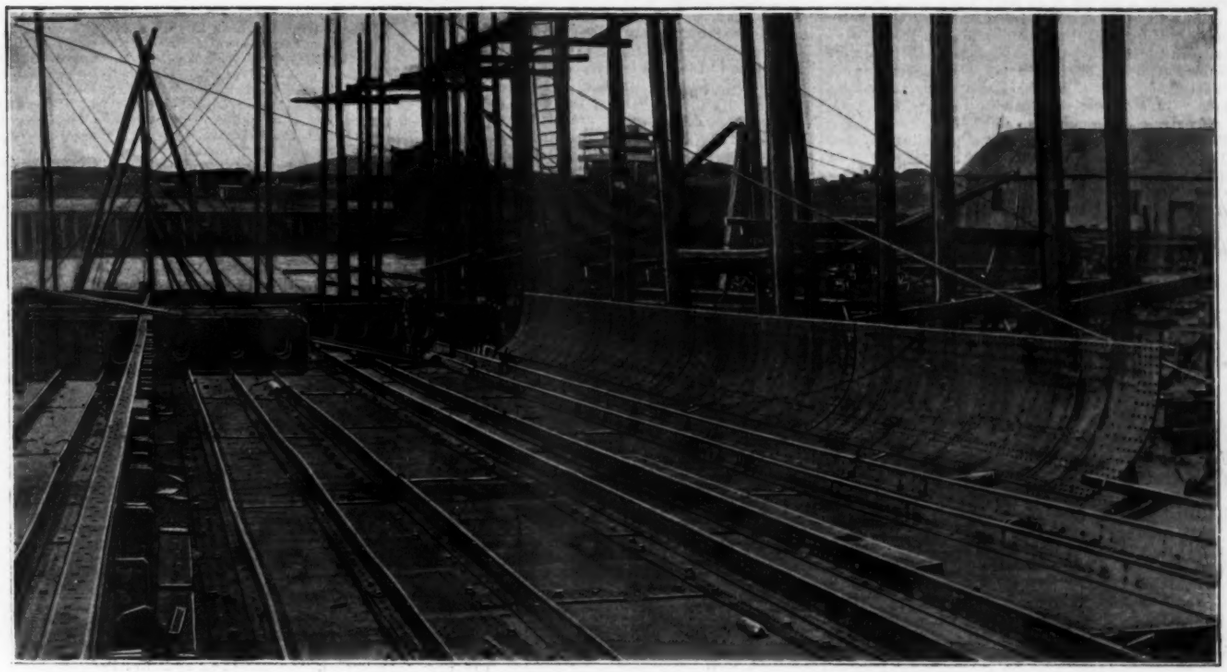


FIG 6.

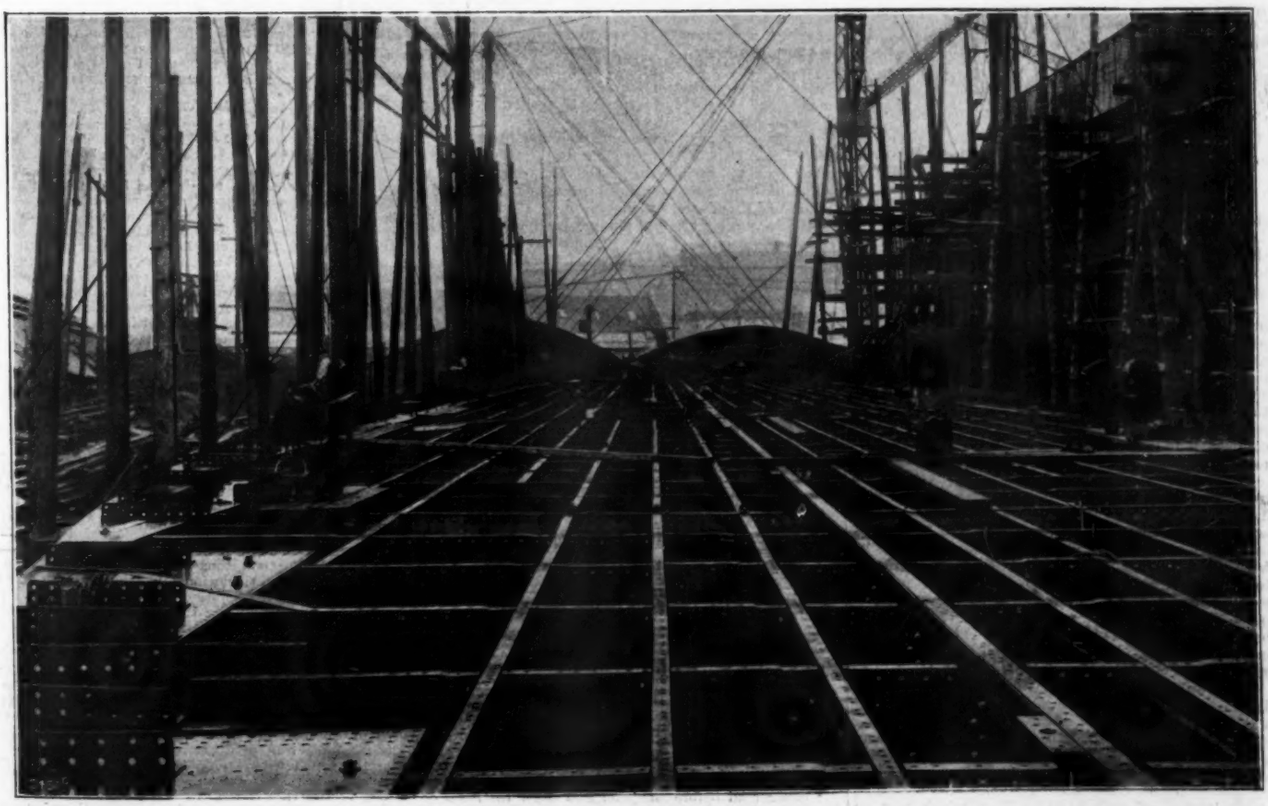


FIG. 7.

experience in the repair of ships which had been subjected to strain in a seaway, and proof of advantage is afforded by the fact that the classification societies make a reduction in thickness of plates where longitudinals are fitted, because the strength is applied in the right direction. Not only is there increased strength, but a saving of at least 5 per cent. in steel, as compared with a ship having ordinary transverse framing. Moreover, the longitudinal bottoms give greater freedom inside the tanks between bottoms for cleaning, painting or repairing. The association of vertical frames with longitudinal members obviates breakage of stowage, the sparring in the side walls running straight through from end to end.

Figs. 1 to 4, on page 512, give a longitudinal section and deck and tank top plans of a ship constructed on this system, while Fig. 5 is a mid-ship section showing the details of construction for a double bottom, side framing and deck longitudinals. It will be seen that

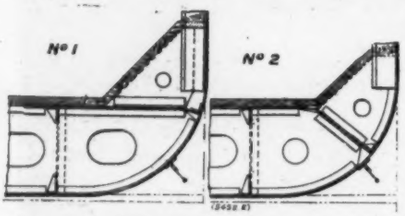


FIG. 8. ALTERNATIVE BILGE ARRANGEMENTS.

the longitudinals are placed parallel to the middle line, and are spaced 2 ft. 6 in. apart, extending from bilge to bilge. To ensure transverse strength in combination with longitudinal strength, and to support the bottom plating of the ship and the tank top, there are transverse floor plates about 6 ft. to 12 ft. apart, instead of from 26 in. to 30 in., as would be the case in a ship where the main framing of the bottom was transverse. The deck beams are similarly arranged longitudinally, with reinforced plate beams placed in a transverse direction at intervals of 12 ft. These are connected to strong reinforced vertical frames on the side of the ship, which are similarly connected at the bottom to the tank top or margin plate, as the case may be. The transverse deck beams are slotted, so that the fore and aft members are continuous, but they are connected to the deck plating as in the case of the longitudinals. These beams can be made so as to show clear holds without pillars, or they can be made to suit two rows of pillars. The perspective views on page 513 show the construction of the double bottom, Fig. 6 showing the double bottom plate, while Fig. 7 shows the main longitudinals in position with the transverse reinforcing frames.

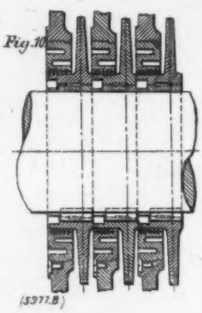
3,000-KW. COMPOUND DE LAVAL STEAM TURBINE AT GOTHENBURG.

ON Plates XLVII to L we this week illustrate a steam turbo-generator recently constructed by the de Laval Steam Turbine Company, of Stockholm, for Gothenburg power stations. The turbine is designed to run at 1,500 r.p.m., and drives a three-phase generator rated at 3,000 kw., the current being delivered at 6,000 volts, with a periodicity of 25 cycles per second. An overload of 20 per cent. can be carried permanently. The general characteristics of the set are clearly shown in Figs. 1 and 2, Plate XLVII and in Fig. 3, Plate XLVIII; whilst a view of the steam end is reproduced in Fig. 6, Plate L, and a longitudinal section through the turbine in Fig. 5, on the same Plate. It will be seen that the turbine is of the compartment, compounded-impulse type, with a two row velocity compounded stage at the high-pressure end.

The casing is of cast-iron, a special quality being used for the intermediate pressure end cover, which has to withstand high temperatures. The nozzle boxes are outside this cover and, as best seen in Fig. 2, independent-travel operated valves are provided by which the number of nozzles in use can be adjusted to the load on the generator. Provision for the expansion of the casing is made at the intermediate-pressure end, which is supported on an independent bedplate by a sliding foot. The back end, as indicated in Fig. 3, Plate XLVIII, rests on two cantilever extensions of the generator bedplate.

The diaphragms are of cast-iron and are slightly dished as shown. They are made in halves, feathered and grooved at the joint in the usual way. To check steam leakage at the inner periphery, the diaphragms are fitted with glands of the type illustrated in Fig. 10, annexed. In accordance with the principle just introduced by Sir Charles Parsons, the actual packing of the joint is effected by these fins; which bear, as shown, on the hub extensions of the wheels. A certain elasticity is provided for by mounting the fins not on the actual diaphragms but on steel bushes, turned to the Z-shape shown in Fig. 10. Carbon glands are used to pack the shaft where it passes through the casing, but to reduce the pressure on these there are fitted supplementary packings similar in character to that adopted for the diaphragms. These wire-draw the steam and deliver it to a lead-off port in the usual way, so that the carbon glands are never subjected to the full steam pressure.

The shaft is a steel forging, and being short and of large diameter, the critical speed of the rotor lies well above the designed running speed. This shaft was finished by grinding both at the bearings and at the wheel seats. These wheels are of forged steel, heat-treated. They are not mounted directly on the shaft, but on removal seats ground to a slight cone externally, and on to these seats the wheels are pressed. Security



against yield under their torque is provided by means of folding keys passing through the seating and into both wheel and shaft.

The buckets, as shown in Figs. 8 and 9, are of the regulation de Laval pattern, and are forced into slots drilled and milled on the periphery of the wheel. A heel, de Laval pattern, and are screwed into slots drilled and milled on the periphery of the wheel. A wheel, complete with its buckets, is represented in Fig. 7, Plate L.

The main bearings are 175 mm. in diameter by 225 mm. long, and run in spherically-seated brasses lined with white metal. The oil is supplied to them under a pressure of 7 lb. to 8 lb. per square, by means of the gear wheel pump shown in Fig. 5, on Plate L. This is fitted at the foot of the governor spindle, which is driven by spiral gearing in the usual way. The governor acts directly on the governor valve without the intermediary of a relay, and the usual emergency governor is fitted, which cuts-off steam should the speed exceed the normal by 15 per cent. A speeder is provided as usual for adjusting the generator voltage as circumstances require.

As shown in Fig. 3, the turbine is mounted directly above its condenser, provision for expansion being made by a concertina pipe of the usual kind. A plan view of the condenser is represented by Fig. 4, Plate XLIX. There are, it will be seen, two sets of motor-driven circulating pumps, each of which can supply 860 cub. ft. of water per minute.

THE JURASSIC IRONSTONES.*

The Jurassic Ironstones of the United Kingdom—Economically Considered.

By F. H. HATCH, Past-President of the Institution of Mining and Metallurgy.

INTRODUCTION.

THE exigency of the war has directed increased attention in this country to the large reserves of low-grade phosphoric ironstone in the Jurassic formation.

The output from the richer blackbands and clay-ironstones of the Carboniferous formation, once so important, has in recent years shrunk to comparatively small dimensions, the thicker, more accessible and more profitable seams having long since been exhausted: it is therefore to the Jurassic ironstones that we must look for the developments of the future.

Having been associated in the Ministry of Munitions in the work of my friend and colleague, Mr. Frank Merricks, in stimulating the production of iron ore from these home resources, I have had an exceptionally favourable opportunity of collecting particulars regarding their distribution, composition and output, which, it appeared to Mr. Merricks and myself, might be usefully put into the form of a paper for the information of the members of the Iron and Steel Institute.

I am indebted for information and suggestions to the following friends in the Department of Iron and Steel Production: Messrs. A. A. Dolan, E. Edwards, F. W. Harbord, F. L. MacLeod, R. E. Palmer, A. K. Reese, H. L. Scott, G. E. Stephenson and H. B. White, also to Mr. J. S. Hollins of the Brymbo Steel Company, Mr. Francis Samuelson of Sir B. Samuelson and Co. the Hon. G. W. Winn of the Frodingham Ironstone Mines and the many ironmasters who have supplied the works' analyses on which much of this paper is based.

* Paper read before the Iron and Steel Institute on Thursday, May 2, 1918. Published by permission of the Controller of Iron and Steel Production, Ministry of Munitions.

PART I.—GENERAL DESCRIPTION.

DISTRIBUTION.

The bedded oolitic ironstones of Jurassic age have a wide distribution both in this country and on the Continent in Luxemburg and Lorraine; and it is noteworthy that it was mainly by the exploitation of the portion of the Lorraine iron-basin ceded by France after the Franco-Prussian War that Germany was able to build up the immense iron trade which, in the years immediately preceding the war, was such a striking feature of her industry.* It is certain that had not Germany possessed Lorraine she could not have entered upon the present war; and it is significant of the importance placed by her on this iron ore field that her first step, after the commencement of hostilities, was the capture from the French of its remaining portion (the Longwy and Briey basins), the loss of which, so early in the war, was such a serious blow to the iron manufacture of France.

In England the Jurassic formation stretches as a broad band from the coast of Yorkshire to that of Dorset. It comprises clays, sand and limestones, bedded nearly horizontally. Locally the beds are gently flexed, and fault disturbances are ocasionally met with. On the whole the dip is to the south-east at an angle which, always small, in Rutlandshire and Northamptonshire averages even less than 1 deg. While the clays and sands have featureless outcrops, the escarpment of the harder calcareous beds form well-marked hill ranges, of which the Cleveland Hills, Edge Hill and the Cotswolds may be cited as examples. The ironstones do not occur as continuous beds in this formation. They are, rather, local developments on particular horizons and, traced laterally, sooner or later pass into limestone, sand, or clay as the case may be. As a consequence of the small angle of dip, the outcrops are wide, and the covering of soil, sand and clay needs only to be removed to expose large quantities of ironstone that can be cheaply extracted by open-cast work or quarrying.

The Jurassic ironstones occur on four different horizons. Taken in descending order these are as follows:—

1. The Corallian beds, between the Kimeridge and Oxford clays. (At Westbury in Wiltshire and near Dover in the Kent Coalfield.)
2. The lower part of the Inferior Oolite (South Lincolnshire, Rutlandshire, and Northamptonshire.
3. The upper part of the Middle Lias (Cleveland in Yorkshire, South Lincolnshire, Leicestershire and Oxfordshire).
4. The middle part of the Lower Lias (near Frodingham and Scunthorpe in North Lincolnshire).

Of these the Corallian ironstone of Westbury and Dover is, at present, not worked as a source of iron; but the ironstone beds of the Inferior Oolite (the Northampton Ironstone), of the Middle Lias (the Marlstone) and of the Lower Lias (the Frodingham Ironstone), accounted in 1917 for as much as 80 per cent. of the total iron ore production of the United Kingdom and for 90 per cent. of the output of phosphoric ore.

OUTPUT.

Although poor in iron the Jurassic ironstones are of great economic importance, being of considerable thickness and superficial extent at only a slight depth below the surface. Moreover, the variability of the lime and silica content that obtains can be counteracted by drawing furnace supplies from different districts. With the exception of the Cleveland district, where the workings are now exclusively underground, the ironstone is, for the most part, quarried at the surface, after the removal of a varying overburden of soil, sand, or clay. The yield per man employed in the open workings varies from 3·8 tons per shift, where hand-labour is alone employed, to over 15 tons where mechanical excavators are in use under favourable conditions. From returns made to the Ministry of Munitions during a week in December, 1917, it appears that the total labour (British) employed on quarrying ironstone in the Midlands (South Lincolnshire, Rutlandshire, Northamptonshire, Leicestershire and Oxfordshire) totalled 2,900 men, the output of ironstone for the same week being 82,280 tons. This gives an average output per man employed of 5 tons per shift. The output per man of ironstone won underground is, of course, much less. Thus, in the Cleveland mines, the output for a week in December was 100,100 tons, and to get this 7,973 men were employed underground and on surface—being an average of 2·2 tons per man per shift.

During 1917 the Jurassic ironstones yielded 12,117,000 tons, or 80·7 per cent. of the total output of the United Kingdom (15,000,000 tons in round figures). Since, as is seen by the calculation given below, this output had an average iron-content of 27·6 per cent., the equivalent amount of pig iron is 3,615,000 tons, the usual impurities of pig iron having been allowed for at 7½ per cent.

The production and average iron-content of the different ironstones as mined or quarried are as follows:

* During 1913, Germany produced nearly 36,000,000 tons of iron ore, of which 28,000,000 tons were minette ores of Jurassic age from Lorraine and Luxemburg. The total pig iron production was close on 18,000,000 tons, of which between 8,000,000 tons and 9,000,000 tons were furnished by these Jurassic ironstones. It is well known that it was the introduction of the Basic Bessemer process that gave the impetus to the use of these low-grade phosphoric ores: in 1897 the output of iron ore in German Lorraine was only 830,000 tons.

3,000-KW. COMPOUND DE LAVAL STEAM TURBINE AT GOTHENBURG.

CONSTRUCTED BY THE DE LAVAL STEAM TURBINE COMPANY, ENGINEERS, STOCKHOLM.

(*For Description, see Page* 514.)

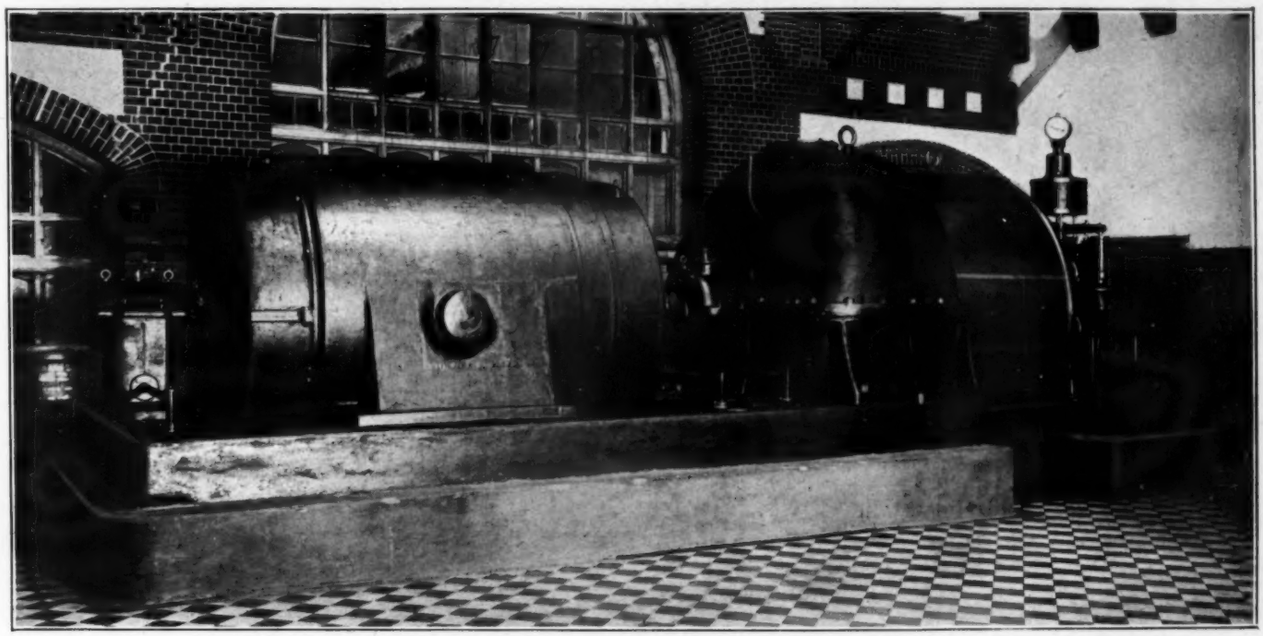


FIG. 1.

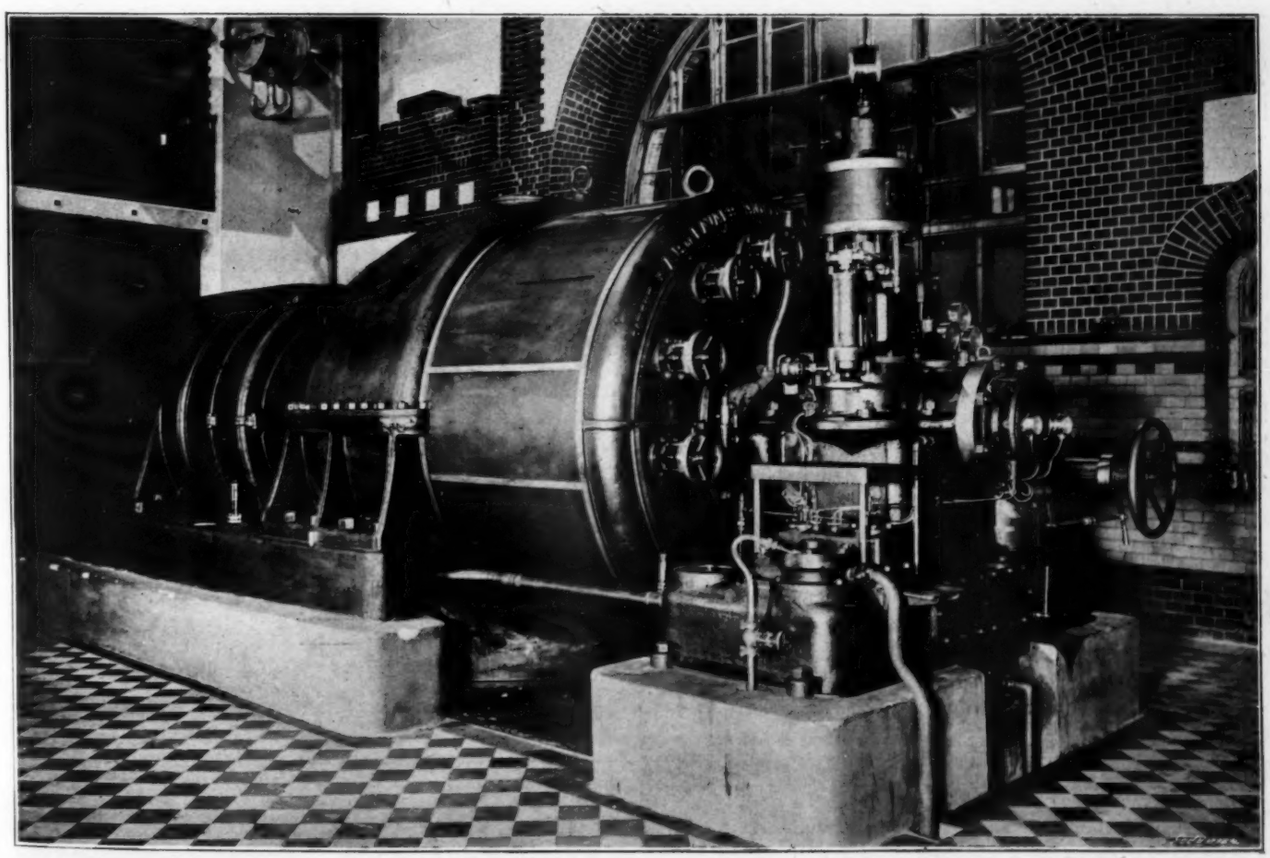


FIG. 2.

(*To face page* 514.)

3,000-KW. COMPOUND DE LAVAL STEAM TURBINE AT GOTHENBURG.

CONSTRUCTED BY THE DE LAVAL STEAM TURBINE COMPANY, ENGINEERS, STOCKHOLM.

(*For Description, see Page* 514.)

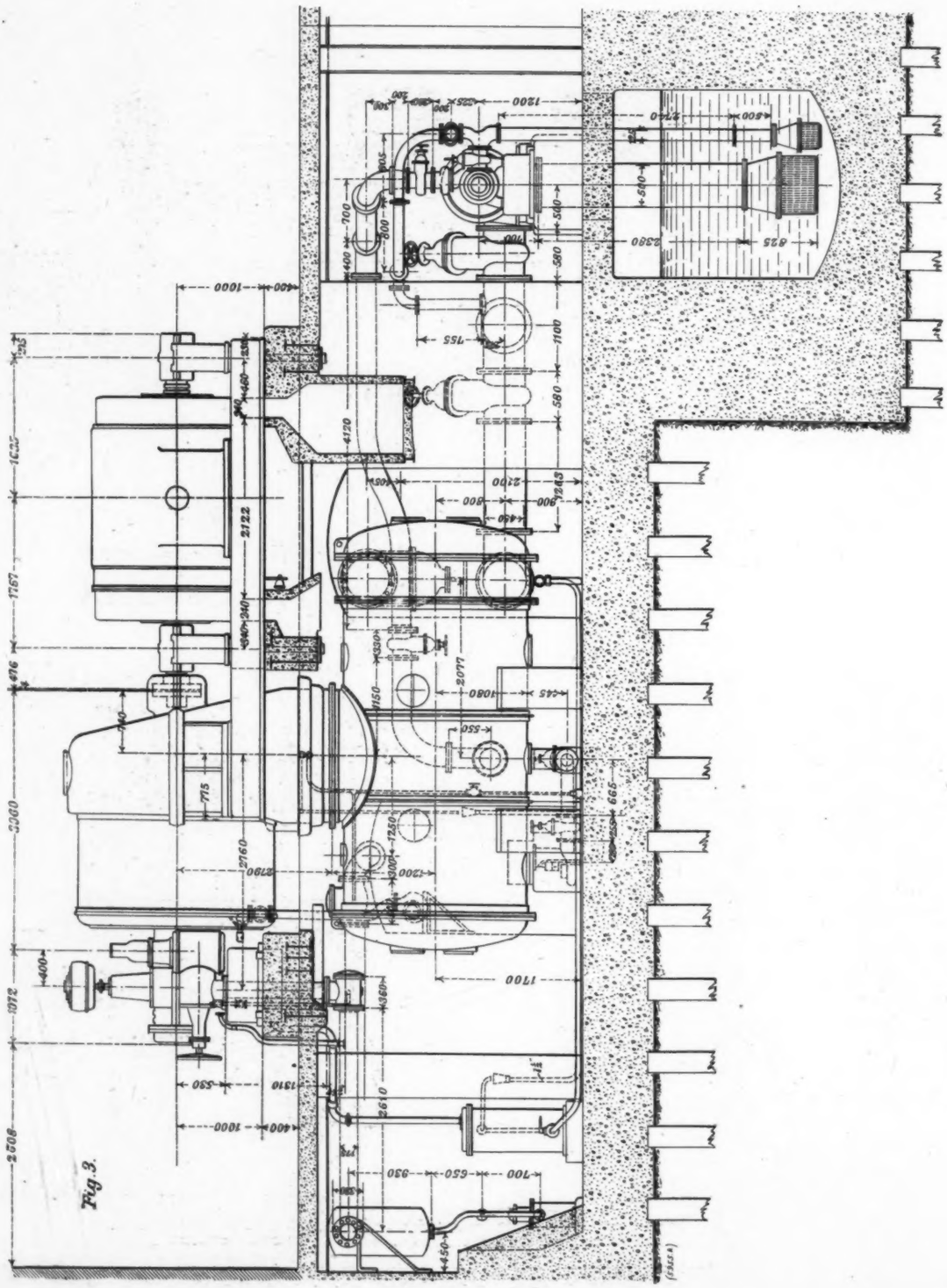
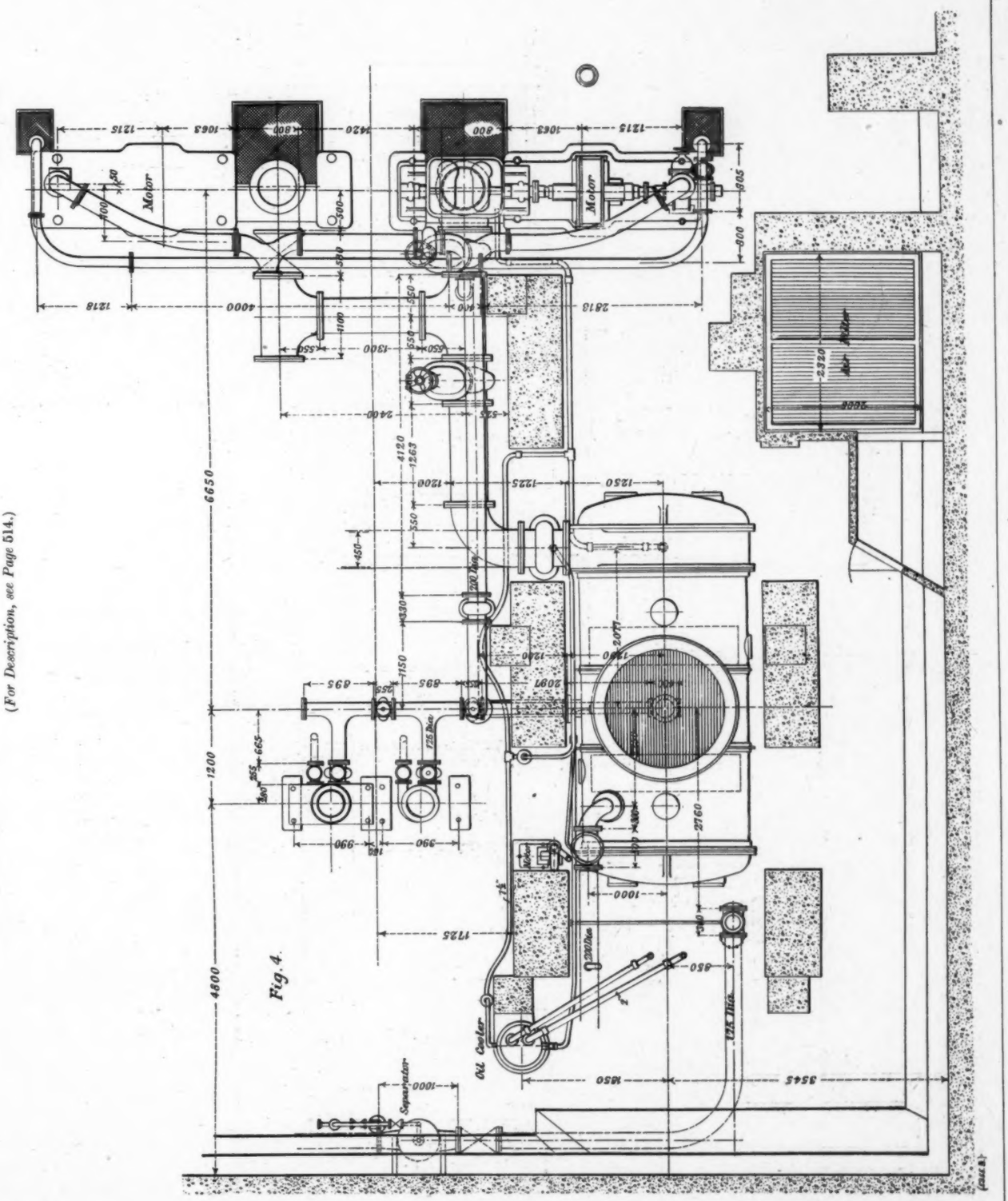


Fig. 3.

3,000-KW. COMPOUND DE LAVAL STEAM TURBINE AT GÖTHENBURG.

CONSTRUCTED BY THE DE LAVAL STEAM TURBINE COMPANY, ENGINEERS, STOCKHOLM.

(For Description, see Page 514.)

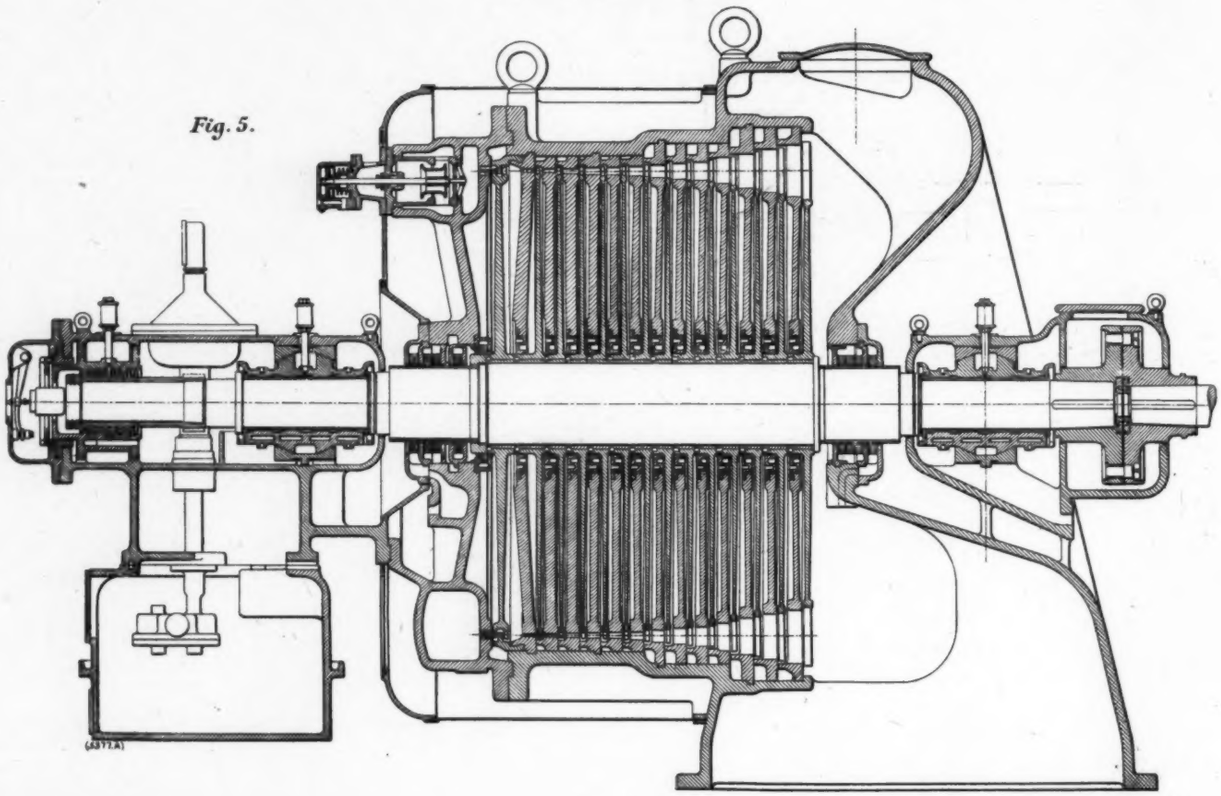


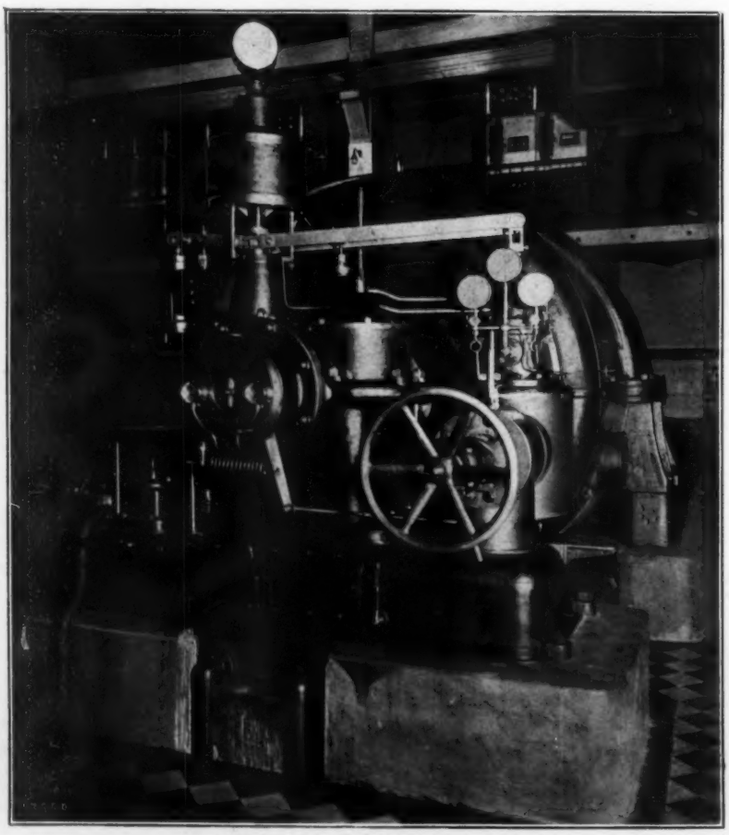
3,000-KW. COMPOUND DE LAVAL STEAM TURBINE AT GOTHENBURG.

CONSTRUCTED BY THE DE LAVAL STEAM TURBINE COMPANY, ENGINEERS, STOCKHOLM.

(*For Description, see Page* 514.)

Fig. 5.





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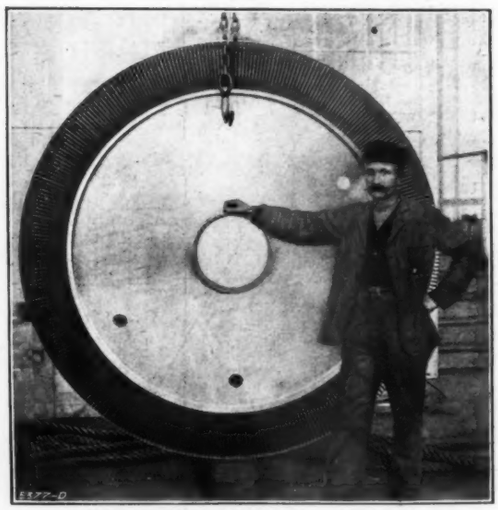

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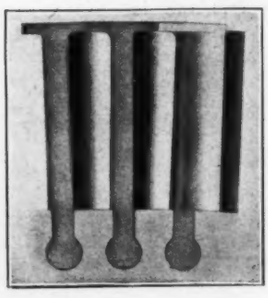

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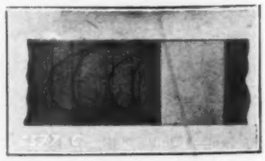


FIG. 9.

(*To face page* 515.)

Jurassic Ironstones.	Production in 1917. Tons.	Average Iron-Content. Per Cent.
Northampton stone (Inferior Oolite)	3,169,110	32·5
Cleveland stone (Middle Lias)	4,809,861	28·1
Leicestershire stone (Middle Lias)	937,707	25·2
Oxfordshire stone (Middle Lias)	434,435	24·0
Frodingham stone (Lower Lias)	2,699,532	22·7
Raasay stone (Upper Lias) ...	65,985	23·0
Total ...	12,116,620	27·6

The output from mines and quarries working in the productive formations of the Jurassic during 1917 was made up as follows:

Formation.	District.	Output. Tons.	Total. Tons.
Inferior Oolite* (Northampton ironstone)	S. Lincolnshire ..	58,726	
	Market Overton ..	585,121	
	Uppingham ..	168,760	
	Kettering	2,275,314	
	Ilsworth	81,189	
			3,169,110
Upper Lias ..	Raasay	—	65,985
Middle Lias (Marlstone)	Cleveland	4,809,861	
	S. Lincolnshire ..	157,682	
	Leicestershire ..	780,025	
	Oxfordshire (including Byfield)	434,435	
			6,182,003
Lower Lias (Frodingham stone)	North Lincolnshire	—	2,699,532
	Grand total		12,116,630

* Iron stone is also worked to a small extent on this horizon in the Cleveland District of Yorkshire (viz., at the East Rosedale mine the output of which is included in the Cleveland total, dealt with in a later section of the paper.

Expressed in percentages of the Jurassic output, the Inferior Oolite was responsible for 26·2 per cent.; the Upper Lias for 0·5 per cent.; the Middle Lias for 51 per cent.; and the Lower Lias for 22·3 per cent.

Disposal of Output.

With regard to the supply of ironstone, the ironmasters require (1) a fairly constant chemical composition, (2) a uniform mechanical condition and (3) a regular delivery. The first of these desiderata is only to be ensured by a careful supervision of the quarrying operations, combined with frequent sampling; further, if the material is to be calcined, care has to be taken to prevent over or under burning.

The importance of maintaining a uniform mechanical condition, in order to secure a regular distribution of the charge in the blast-furnaces, is perhaps not sufficiently realised by quarry owners. Some progress has been made in this direction by the provision here and there of appliances to eliminate the fine material produced during excavation or calcining (*e.g.*, the use of forks, screens, trommels, or other riddling machines); but too often there is an insufficient supervision of mechanical excavation, with the result that large masses of unbroken stone are occasionally sent to the blast-furnaces. There can be no doubt that if breaking to a more uniform size were combined with a systematic elimination of the fines, furnace burdens would benefit, both in regard to physical condition and to chemical composition.

Mr. Hollings informs me that the Brymbo Steel Company at its Oxfordshire quarry at Park Farm does not strip the cover separately when it is less than 3 ft. in thickness. The sandy cover and ironstone are removed together by the same navvy, and the whole material passed through a portable riddling machine which, after elimination of the fines, delivers the stone into tramway trucks for transportation to the calcining kilns. In this way the ironstone nodules in the soil and sub-soil are recovered; while the sandy sterile component of the cover and similar material in the fissures, joints and bedding planes of the ironstone are got rid of, thus raising the iron-content and lowering the silica. The method seems particularly adapted to the Oxfordshire district, where over large areas the cover is light; but no data are available as to the possible effect of this procedure on agriculture.

Regularity of delivery is a matter over which the quarry owner has less control, as it is to a large extent dependent on the prompt return of the empty wagons. Mr. R. E. Palmer, of the Transport Section of the Iron and Steel Production Department, Ministry of Munitions, who has devoted considerable attention to this matter, informs me that the delays are normally due to four chief factors: (1) The diversion of wagons for back-loading purposes from their ordinary return routes. (2) The lack of storage facilities at many of the furnaces, wagons being made use of for this purpose. (3) The absence at many of the furnaces and even at some of the large producing quarries, of a traffic department to deal with the marshalling of the trains and preparing them for rapid discharge. (4) The lack of standardisation throughout the country, producers being only able to load, and receiving firms to discharge, certain special types of wagons. Under a better system it would be possible for a standard type of wagon to circulate freely anywhere.

Mr. Palmer has stationed a number of Ministry Transport Inspectors in the different districts for the purpose of mitigating, as far as is within their power, the above mentioned drawbacks to good deliveries.

Of the approximately 100,000 tons of ironstones produced weekly in the Midlands (using this term to include South Lincolnshire, Rutlandshire, Northamptonshire, Leicestershire and Oxfordshire) two-thirds is classed siliceous and one-third as "limey" or calcareous. Broadly speaking the calcareous stone is derived from the Marlstone of Leicestershire and Oxfordshire, since the Northamptonshire stone is practically all siliceous. The Marlstone, on the other hand, yields both a siliceous and a limey stone. It is a calcareous stone, where it is protected by the nature of its cover from the chemical action of surface waters; but it is siliceous where weathering has led to the removal of the lime.

Of the total weekly output in the Midlands in December, 1917, 27 per cent. was kept in the district for local consumption, and of this 30 per cent. was limey and 70 per cent. siliceous. The local furnaces supplied are situated at Kettering, Islip, Wellingborough, Hunsbury (south of Northampton), Corby (north of Kettering) and Asfordby (near Melton Mowbray), there being in all 16 furnaces. None of the stone going to these furnaces is calcined at the quarries.

Of the stone sent to outlying districts 36 per cent. was limey and 64 per cent. siliceous. The bulk of it (85 per cent.) went to blast-furnaces situated in the coalfields; more particularly to the Derbyshire and Nottingham coalfield, but also to those of Staffordshire and Warwickshire, Yorkshire and Lancashire and South Wales. The balance of 15 per cent. was divided in nearly equal parts between North Lincolnshire and Cleveland, with this difference, that the former took practically all siliceous stone while the latter took a slightly higher proportion of calcareous stone, the character of the local ironstone produced in each of these districts requiring a different class of material for the furnace mixtures.

Of the total Midland output 12 per cent. was (in December, 1917) calcined at the point of origin, the balance being transported to the furnaces in the raw state and either calcined there or fed raw into the furnaces.

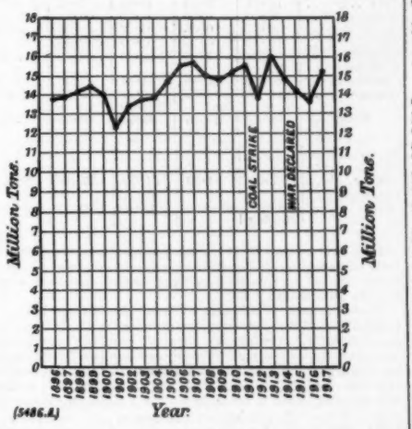


Fig. 1. Home Iron Ore Production, 1896-1917.

Since the stone loses a quarter of its weight on calcination, it is, from a ton-mileage point of view, an advantage to calcine at the place of origin. The subject will be referred to in subsequent sections of this paper.

According to returns made to the Ministry of Munitions in December last only 6 per cent. of the ironstone quarried in North Lincolnshire was siliceous, the balance being limey. Of the total quantity of this stone put on wagons 73 per cent. went to local furnaces (Appleby Iron Company, Frodingham Iron and Steel Company, Redbourn Hill Iron and Coal Company, North Lincolnshire Iron Company, Trent Iron Company and J. Lysaght, Limited—20 furnaces in all), 15·4 per cent. to furnaces situated in the Yorkshire coalfield (Parkgate, Ardsley and Walter Scott), 5·6 per cent. to the Derbyshire and Nottingham coalfield, 4·7 per cent. to the Lancashire coalfield, and 1·6 per cent. to Cleveland.

As regards the Cleveland output, local blast-furnaces take the whole of it. The greater part is required for the production of basic pig for steel-making, the remainder being used for the well-known Cleveland foundry and forge makes, for which there is a large demand.

Composition.

Detailed analyses of the different ironstones and particulars of the methods of arriving at the average composition are given later. It will suffice here to give briefly the figures obtained by averaging the results of more than two hundred analyses made at ironworks. This information was placed at the disposal of the Ministry by the courtesy of their respective owners.

In the following table the average compositions of the various ironstones are compared, both for the stone as received at the blast-furnaces and for stone dried at 212 deg. F.

Raw Stone as Received at the Ironworks.

	Fe.	Mn.	SiO_2.	Al_2O_3.	CaO.	MgO.	S.	P.	Moisture.
Northamptonshire and Rutlandshire — siliceous (Inferior Oolite)	32·5	0·24	14·7	6·1	2·7	0·4	0·10	0·60	15·2
Cleveland, Yorkshire — siliceous (Middle Lias)	28·1	0·41	11·8	10·2	4·7	3·5	0·26	0·47	6·8
Leicestershire and South Lincolnshire — slightly siliceous (Middle Lias)	25·2	0·23	10·9	8·0	9·6	0·6	0·11	0·25	16·4
Oxfordshire— almost self-fluxing (Middle Lias)	24·0	0·27	10·2	7·6	12·2	0·6	0·06	0·23	15·6
N. Lincolnshire— Limey (Lower Lias)	22·7	0·96	8·1	5·1	18·2	1·0	0·16	0·31	10·7

Raw Stone Dried at 212 Deg. F.

	Fe.	Mn.	SiO_2.	Al_2O_3.	CaO.	MgO.	S.	P.
Northamptonshire and Rutlandshire (Inferior Oolite)	38·2	0·28	17·4	7·2	3·1	0·5	0·12	0·71
Cleveland, Yorkshire (Middle Lias) ..	30·2	0·44	12·7	11·0	5·1	3·8	0·28	0·51
Leicestershire and South Lincolnshire (Middle Lias) ..	30·2	0·27	13·0	9·6	11·4	0·7	0·13	0·30
Oxfordshire (Middle Lias)	28·3	0·32	12·0	8·9	14·4	0·7	0·07	0·27
N. Lincolnshire (Lower Lias)	25·4	1·07	9·1	5·7	20·3	1·1	0·18	0·35

On the other hand, the Marlstone of Leicestershire, although also low in iron, carries a considerable proportion of lime, and consequently there is, on the whole, only a slight excess of the acid constituent, even when allowance is made for the effect of the alumina-content. The Marlstone of Oxfordshire has about the same proportions of silica and alumina as the Leicestershire variety; but the Oxfordshire stone has more lime and, taken on the average, may be regarded as self-fluxing.

Part of the Northamptonshire ironstone is smelted locally with limestone or with limey ironstone obtained in the district. Some is sent to Frodingham and some to Middlesbrough for smelting with the ironstones of those districts; but the greater proportion goes to furnaces in the coalfields of Staffordshire, Derby and Nottinghamshire, South Yorkshire and South Wales, to be smelted in admixture with the calcareous blackband and clay-ironstones of the Coal Measures and with tap-cinder.

The Lower Lias ironstone of Frodingham in North Lincolnshire has still less iron; but since the lime is in most cases much in excess of the silica and alumina, the stone is in general limey, and is most advantageously used in admixture with a siliceous ironstone, such as that of Northamptonshire, for which its calcareous constituent serves as a flux.

Although the iron-content of the siliceous ironstones of Northampton and Cleveland is appreciably higher than that of the more calcareous ironstones of North Lincolnshire, Leicestershire and Oxfordshire, this is to some extent set-off by the fact that the lime that has to be added to the furnace charge proportionately reduced the percentage of iron and, since it is less intimately associated with the silica-content of the ironstone than in the limey variety, the furnace mixture is somewhat more difficult to smelt.

With regard to sulphur there is not much to choose between the different ironstones, except that Cleveland is rather higher in this respect, and the presence of both sulphur and alumina in relatively considerable proportions in this stone causes a difficulty in the manufacture of basic pig iron which will be referred to later on in this paper.

Phosphorus is highest in the Northamptonshire ironstone (average, 0·6 per cent.) and lowest in the Marlstone of Oxfordshire and Leicestershire (average, 0·25 per cent.).

Manganese averages about one quarter of 1 per cent. in the Inferior Oolite and Middle Lias ironstones; but in the Frodingham stone it is about 1 per cent. and enables this stone to be smelted without the addition of manganese ore.

PART II.—Detailed Description.

The Inferior Oolite or Northampton Ironstone of Rutlandshire and Northamptonshire.

The particular division of the Inferior Oolite, in which this ironstone occurs, is known as the Northampton Sand. In its upper part it consists of sands with impersistent beds of clay, in which are found evidences of marine, fresh water and terrestrial conditions.* In consequence, this upper part has been designated the Lower Estuarine Series. The lower part, however, consists of undoubted marine beds belonging to the zone of Ammonites Murchisonæ.

Sometimes the whole thickness of the Northampton Sand is made up of white sand with occasional beds of clay; in places it passes into a calcareous oolitic rock; but usually a greater or lesser portion appears as a

* For details of the geology of the Northampton Sand, see Judd's "Geology of Rutland," *Mem. Geol. Survey*, 1875, page 32.

greenish ironstone with oolitic structure. Hudleston,* who wrote on the Northampton ironstone in 1874, considered that it was originally a sandy oolitic limestone, and that the replacement by carbonate of iron took place through the medium of waters holding bicarbonate of iron. He traced the source of the iron to the overlying Estuarine Sands, and suggested that the organic acids which leached out the iron from these beds were furnished by the decomposition of the woody matter they contain.

Where it has been exposed to the oxidising influence of atmospheric waters, the upper portion of the ironstone is changed to a brown or reddish stone, at the same time assuming a distinctly banded or cellular character, which is clearly connected with the planes of bedding and jointing. By means of these openings the oxidising waters were enabled to penetrate into the heart of the rock, the resulting chemical changes being accompanied by a concentration of the newly-formed iron salts on the cell walls, leaving a central sandy portion poor in iron. Sometimes the oxidation has not touched the actual cores, which then consist of the original green ironstone. As a rule, only the upper part of the ironstone is worked, the workable portion being from 6 ft. to 13 ft. and averaging about 8 ft. The lower portion is generally too poor in iron or too siliceous for economic extraction.

Distribution of Workings.—Not everywhere on its horizon is the Northampton ironstone developed, passages to equivalent beds of sand or limestone being easily traced.

The most northerly point at which it is of industrial importance is at Greetwell, immediately east of Lincoln, where it is mined by the Mid-Lincolnshire Iron Company. A little farther south it is worked in an isolated quarry at Leadenham. There are no other workings in this formation in Lincolnshire, except at Buckminster and Stainby, near the Leicestershire and Rutlandshire boundaries, where the ironstone is quarried by the Holwell Iron Company. A little farther south, just over the Rutlandshire border, it is worked by James Pain, Limited, and by the Sheepbridge Iron Company, near Edmondthorpe, Market Overton and Cottesmore. The next group of quarries is in the neighbourhood of Uppingham, in Rutlandshire—these also belong to James Pain, Limited, while on the Northamptonshire border the Partington Iron and Steel Company are opening quarries at Wakerley.

The most continuous workings on the Inferior Oolite ironstone are in Northamptonshire. Quarries extend from Gretton, on the north boundary of this county, to Towcester in the south. The greatest number centre round Kettering, where the outcrop of the ironstone occupies a great expanse of country. Open-cast working is, in this area, only limited in the higher ground by the increase in thickness of the capping of the clays and sands of the Upper Estuarine Series and, in places, of the Lincolnshire Limestone. On the other hand, in the lower ground it is limited by denudation in those places where the rivers have cut down through the ironstone into the underlying Upper Lias clay.

To the north of Kettering there are workings near the villages of Gretton, Rockingham, Corby, Geddington and Weekley, belonging to Lloyds Ironstone Company, E. P. Davis and James Pain, Limited ("Glendon mines"); to the west are those of Desborough, Rothwell, Orton and Loddington, belonging to the Sheepbridge, Stanton, Stabeley and Kettering Coal and Iron Companies, and to James Pain, Limited; to the east, those of Islip, Twywell and Cranford, belonging to the Islip Iron Company and to the Staveley Iron Company; while to the south the Burton Ironstone Company and C. Barlow work the ironstone near Burton Latimer, Finedon and Irthlingborough. A little farther to the south are the Wellingborough quarries belonging to the Wellingborough Iron Company, to J. Clarke and to James Pain, Limited; while to the south-east there is a group of quarries near the villages of Brixworth belonging to the Brixworth Ironstone Company.

Between Wellingborough and Northampton there are isolated quarries at Earlsbarton (worked by the Earlsbarton Ironstone Company) and at Whiston (worked by the Whiston Ironstone Company); while to the south of Northampton, quarries are worked at Wooton, Danes Camp, Gayton Wood, Blisworth and Towcester, by the executors of P. Phipps, by R. B. Sparrow and by the Towcester Mining and Brick Company.

Method of Open-Cast Working.—After opening a quarry by driving in a cutting or "gullet," first through the "overburden" or "cover" and then through the ironstone, the operations of stripping the cover and getting the ironstone are commenced. The cover, which varies from a few inches of soil up to 35 ft. or 40 ft. of sand and clay, is removed and deposited on the other side of the cutting, at first on virgin ground, whence it has subsequently to be removed, but afterwards on ground from which the ironstone has already been won. Several types of machines are used for stripping the cover; *e.g.*, endless bucket excavators, long-jib crane-navvies, grabs and drag-line excavators.† The material is conveyed to the dumping ground by "transporters" with endless rubber belts, or travelling skips (see illustrations on page 520).

The ironstone, after being shaken up by blasting, is dug and loaded, either by hand, or by crane-navvies, into wagons for transportation to the blast-furnaces, or to the local calcining kilns or heaps ("clamps"). Before the worked-out ground is restored to agricultural purposes it is levelled and the soil replaced.

* W. H. Hudleston, *Proceedings of the Geological Association*, 1874, vol. iv, page 123; 1889, vol. xi, page 108.

† For a description of the mechanical appliances used for stripping cover and getting ironstone, see a paper by W. Barnes in the *Iron and Coal Trades Review* for April 5, 1918.

SOURCES OF INFERIOR OOLITE IRONSTONE WHICH WAS ANALYSED.

No. of Analysis.	Situation of Quarry.	Owners.	Source of Information.
1.	Brixworth, near Kettering, Northamptonshire	Brixworth Ironstone Company ..	The Midland Coal, Coke and Iron Company.
2.	"Glendon Mines," Kettering.	James Pain, Limited	" " "
3	Earlsbarton, E of Northampton	The Stanton Ironstone Company	" " "
4.	Uppingham, Rutlandshire	James Pain, Limited	J. Lysaght, Limited.
5.	Greetwell, S. Lincolnshire	The Mid-Lincolnshire Iron Company	The Trent Iron Company.
6.	Desborough, near Kettering, Northampton ...	The Sheepbridge Iron Company ..	The Midland Coal, Coke and Iron Company.
7.	Easton, near Stamford, Northamptonshire ..	The North Lincolnshire Iron Company	The Frodingham Iron and Steel Company.
8.	Buckminster, S. of Grantham, S. Lincolnshire	The Holwell Iron Company ..	The Parkgate Iron and Steel Co.
9.	" " "	" " ..	The Holwell Iron Company.
10.	Finedon, near Wellingborough, Northamptonshire.	Charles Barlow	The North-Eastern Steel Company.
11.	Buckminster, S. of Grantham, S. Lincolnshire	The Holwell Iron Company ..	The Holwell Iron Company.
12.	Corby, near Kettering, Northamptonshire. ..	Lloyds Ironstone Company ..	Bell Brothers, Clarence Iron Works.

SELECTED ANALYSIS OF INFERIOR OOLITE IRONSTONE.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
—	Brixworth.	"Glendon Mines."	Earlsbarton.	Uppingham.	Greetwell.	Desborough.	Easton.	Buckminster.	Buckminster.	Finedon.	Buckminster.	Corby.
Fe	23·76	27·61	28·69	29·50	30·04	32·14	32·20	32·23	32·91	34·92	34·97	35·60
Mn	0·18	0·36	0·27	0·12	0·11	0·19	0·13	—	0·31	0·31	0·33	0·20
SiO_2	8·26	13·28	17·05	15·12	15·50	12·27	22·87	17·30	14·90	10·38	15·83	7·89
Al_2O_3 ..	7·06	7·67	10·21	6·53	7·10	7·31	5·22	7·10	5·55	7·16	5·89	6·66
CaO	15·77	3·86	0·42	4·82	5·70	3·47	1·23	1·60	0·62	3·14	0·66	2·15
MgO	0·59	0·66	0·39	0·84	0·72	0·49	0·63	—	0·31	0·72	0·33	0·81
S	0·11	0·05	0·17	0·08	0·13	0·06	0·01	0·03	0·07	0·22	0·08	0·12
P	0·76	0·98	0·60	0·59	0·33	0·55	0·49	0·76	0·70	0·64	0·75	0·39
Moisture ..	12·00	19·50	15·60	16·40	15·60	15·40	12·60	14·10	20·00	12·86	15·00	18·34
Combined water and CO	20·24	12·88	13·34	13·03	12·10	13·53	9·39	12·80	9·52	13·85	10·12	12·37
Oxygen ..	11·21	13·12	13·17	13·37	12·18	14·51	14·42	13·87	15·11	15·80	16·04	15·56
Total ..	99·94	99·97	99·91	100·40	99·51	99·92	99·19	99·79	100·00	100·00	100·00	100·09
Fe in sample dried at 212 deg. F. ..	27·00	34·30	34·00	35·30	35·59	37·37	36·90	37·60	41·14	40·00	41·14	43·60
Character of stone ..	Self-fluxing	Siliceous	Siliceous	Siliceous	Siliceous	Siliceous	Siliceous	Siliceous	Siliceous	Siliceous	Siliceous	Siliceous

In a few cases, as at Leadenham, the cover contains beds of limestone (Lincolnshire Limestone), and the ironstone cannot be quarried until a market has been found for the limestone.

Underground Workings.—When the cover increases to about 40 ft. in thickness, it cannot, as a rule, be removed economically. Under favourable working conditions, however, the extraction of the ironstone can be continued by mining. Tunnels or adits are run in from the surface, and the mine laid out on the "bord-and-pillar" system. The broken stone is brought to the surface by horse and other form of mechanical haulage, or traction; at Irthlingborough the pit-tubs will be brought direct to the top of the calcining kilns.

The mining of Northampton stone, as distinct from quarrying, has hardly yet been seriously taken in hand; but underground work is in progress at Greetwell by the Mid-Lincolnshire Iron Company, at Cranford St. John by the Clayeross Iron Company, at Slipton and Twywell by the Islip Ironstone Company, at Stanton Gate, near Wellingborough, by the Stanton Ironworks Company, at Thingdon, near Wellingborough, by the Wellingborough Iron Company, and at Irthlingborough, near Finedon, by the Ebbw Vale Company.

Calcining.—The bulk of the ironstone is sent out of the district in the raw state. A small proportion (about 11 per cent. of the total output) is calcined locally. This is usually done in open heaps or "clamps," where the volatile constituents (water and carbon dioxide) are driven off by a slow roasting process, the fuel required for the purpose being about 1½ cwt. of coal to the ton of ironstone. Kilns are not generally used; but at Irthlingborough, near Wellingborough, the Ebbw Vale Company are erecting 16 kilns to calcine the output of their mine, which, when the latter is producing at its full capacity, will amount to 2,000 tons of raw stone per day.

Some of the stone is calcined after delivery to the furnaces, but a considerable proportion is fed to the furnaces in the raw state. An increase in the amount calcined at the point of origin would save ton-mileage; and the substitution for raw stone at the furnace of such calcined material as the condition of the "burden" will permit would save fuel while increasing the output of pig iron per furnace. The use of all calcined stone in the furnaces is objected to on account of the dust it contains. A remedy for this might be found in screening. If the volatile constituents are completely driven off, Northampton ironstone loses between 27 per cent. and 28 per cent. of its weight; but in practice the calcination is incomplete and the calcined material, if reheated to redness, loses at least a further 3 per cent. to 4 per cent.

Owing to an insufficiency of data, I have not been able to arrive at satisfactory figures for the average composition of calcined Northampton stone. Such analyses as have been furnished by the ironmasters indicate a considerable variation in composition. Thus the iron in the calcined material as received at the ironworks varies from 35 per cent. to 44 per cent., the silica from 11 per cent. to 26 per cent., the moisture from 1 per cent. to 6½ per cent. and the further loss on ignition from 2½ per cent. to 9½ per cent. If, in the course of the discussion of this paper, further figures relating to the composition of calcined stone can be supplied, it will, I think, be of advantage to the industry.

Chemical Composition.—In order to ascertain the average composition of the Northampton ironstone, a considerable number of analyses were obtained from blast-furnace owners who use this ironstone as part of the ore burden; and these analyses have been grouped according to the location of the quarries from which the ironstone was obtained. The following localities are represented, the number of analyses used being shown in brackets—Greetwell (4), Leadenham (1), Cottesmore (3), Easton (3), Buckminster (4), Uppingham (4), Market Overton (3), Corby (3), Kettering (16), Desborough (9), Loddington (2), Lamport (1), Brixworth (2), Burton (2), Cranford (3), Finedon (5), Wellingborough (13), Earlsbarton (1), Whiston (8), making 87 in all. The percentages were averaged first for each group and then for the whole, regard being paid to the output of each group by the introduction into the calculation of a tonnage factor.

The following is a summary of the results :—

No. of Analyses used in the Calculations.	—	Calculated Average. As Received.	Calculated Average. Dry.
87	Fe	32·49	38·23
54	Mn	0·24	0·28
87	SiO_2	14·75	17·39
67	Al_2O_3	6·11	7·20
82	CaO	2·66	3·12
45	MgO	0·45	0·53
57	S	0·10	0·12
57	P	0·60	0·71
87	Moisture	15·20	—
	Combined water, CO_2, and O by difference	27·40	32·42
		100·00	100·00

The ranges of the percentages of the different constituents in the analyses used are as follow :—

	Per cent.	Per cent.
Iron	from 37·61	to 20·63
Manganese	„ 0·60	„ 0·09
Silica	„ 28·80	„ 7·89
Alumina	„ 11·70	„ 1·78
Lime	„ 11·65	„ 0·42
Magnesia...	„ 0·84	„ 0·03
Sulphur	„ 0·50	„ 0·02
Phosphorus	„ 0·95	„ 0·30
Moisture	„ 23·90	„ 4·93

The considerable variation in these figures is chiefly attributable to the existence of the two types of ironstone already referred to, viz., (1) a green unaltered lower portion in which the iron is in the ferrous state, partly as carbonate and partly as silicate: this type is low in iron and comparatively high in lime; and (2) a red upper altered portion in which the iron is oxidised and hydrated, and the leaching out of the lime has raised the

percentage of all the other constituents: this type is comparatively high in iron and silica.

The proportion in which these two types occur depends on the composition and thickness of the cover. When the cover is permeable and thin the atmospheric waters, having free access, remove the lime and effect the oxidation and hydration of the iron. On the other hand, when the ironstone bed is covered by a sufficient thickness of clayey or shaley strata more or less impervious to water the iron may be present in the ferrous state, even close up to the junction of the bed with its cover. As already explained, only the upper portion of the ironstone is worked, since there is a deterioration in the iron-content downwards. Since, however, the passage is very gradual and occurs at different levels, a certain proportion of the green ironstone is also quarried.

The selected complete analyses are given on the preceding page. They represent the composition of bulk samples of the raw ironstone as received at the ironworks.

THE MIDDLE LIAS IRONSTONE OR "MARLSTONE" OF SOUTH LINCOLNSHIRE, LEICESTERSHIRE AND OXFORDSHIRE.

Distribution of Workings.—The Middle Lias ironstone, or Marlstone, is nowhere worked between Cleveland in Yorkshire and South Lincolnshire. But, commencing at a point ten miles north of Grantham, it is extensively quarried along the outcrop in the latter county, and across the Leicestershire border to within three miles of Melton Mowbray. The South Lincolnshire quarries north of Grantham are situated at Fulbeck (E. P. Davis), at Caythorpe (W. Burke), at Barkston and Honington (Stanton Ironworks Company); while south-west of Grantham the ironstone is worked at Woolsthorpe, Denton and Harston (Stanton Ironworks Company).

In Leicestershire the Marlstone is worked by the Holwell Iron Company, the Waltham Iron Ore Company, and the Eastwell Iron Ore Company, in a group of quarries situated near the villages of Eaton, Eastwell, and Stathern; while a little farther to the south it is worked by the Stanton Ironworks Company, at Holwell, Wartnaby, and Tilton.

The ironstone is not worked south of Melton Mowbray and north of Daventry in Northamptonshire. South of the latter town, near the Oxfordshire boundary, two quarries are worked by the Northamptonshire Ironstone Company, near Byfield, and one is being opened up by the Parkgate Iron Company at Hellidon.

In Oxfordshire quarries are worked in the Marlstone at Hook Norton by the Brymbo Steel Company and by H. W. Baker; at Milton by the Bloxham Ironstone Company; at Adderbury by Messrs. Cochrane and Co.; at Astrop and Sydenham by Messrs. Hickman, Ltd., and at Blosham by the Northamptonshire Ironstone Company.

The working of the ironstone in Oxfordshire has been handicapped by the absence of railway communication; consequently a big area of ground has till recently remained dormant. It has now been explored by sinking pits, and steps are being taken to open it up. Thus a railway is being constructed to connect new areas at Wroxton, N.W. of Banbury, belonging to the Oxfordshire Ironstone Company, with the Great Western Railway at a point some two miles north of Banbury. These areas are being opened up to supply Oxfordshire stone to furnaces in South Wales. A light railway has also been projected to connect with the Stratford-upon-Avon and Midland Junction Railway, with the object of opening up a district which, on the north west, extends to the Edge Hill escarpment overlooking the Lower Lias plain of South Warwickshire.

Method of Working.—The methods of stripping and excavating the Marlstone are identical with those used in working the Northampton ironstone (see Fig. 4, page 520). The greatest thickness of cover economically removable is about 15 ft. When the cover has a greater thickness than this, the percentage of iron in the stone is usually too low for profitable working. This is due to the fact that, in consequence of the protection afforded by the greater overburden, the leaching-out of the lime and consequent increase of the iron-content has not taken place to any appreciable degree.

As a rule the Marlstone is sent away raw, but a mild calcination in Davis Colby kilns, in which little more than the moisture is driven off, is carried out by the Brymbo Company at their quarries in Oxfordshire. Messrs. Hickman have Gyers kilns at Astrop and are erecting others at Sydenham where they propose to calcine with a low-pressure blast.

(To be continued.)

RETFORD BOILER EXPLOSION.—The formal investigation ordered by the Board of Trade to be held in this matter is fixed for hearing in the Court House, Retford, Notts., on Tuesday, the 14th inst., at 11 a.m.

ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN. SOUTH-EAST LONDON AND DISTRICT BRANCH.—A general meeting of members of this branch was held at the Shakespeare Hotel, Woolwich, S.E., on Saturday, April 27. A membership of 200 in October, 1917, has grown to over 440 at the present time. A matter that is becoming one of serious importance was referred to at this meeting—the unfair restriction of movement imposed on draughtsmen by Section 8B of the Defence of the Realm Act Regulations. Apart from the economic side of the question, the future prospects of the younger members of the profession are likely to suffer from inability to secure the experience necessary for their development. This branch comprises the counties of Kent and Essex, and particulars may be obtained from the Branch Secretary, Mr. A. H. Glasspole, 12, The Brent, Dartford, Kent.

COPPER TUYERES FOR BLAST FURNACES.*

By A. K. REESE, Cardiff.

THE use of copper tuyeres in blast-furnace operation is a phase of modern practice which has still a wide field for adoption in this country, as many furnace managers continue to use the old cast-iron tuyere made by running cast-iron around a coil of pipes bent to the desired shape. The copper tuyere consists of a hollow copper casting—or forging with cast copper, brass, or steel outer end—with walls from ⅜ in. to ½ in. thick, the cooling water being led to the nose or inner end of the tuyere by a thin brass tube attached to the inlet opening, and extending to within about 3 in. of the nose, thus insuring a good circulation of cold water through the portion of the tuyere which is subjected to the greatest heat. Fig. 1 shows a section through a cast copper tuyere, and the dot-dash lines at X mark the position of the brazed joint in making a forged copper tuyere of the same section.

Fig. 1. SECTION OF COPPER TUYERE
If of forged or rolled copper the parts are joined by brazing at X

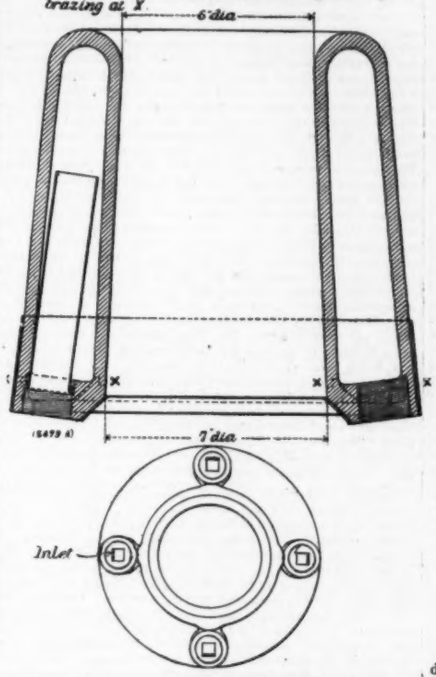


Fig. 2. COPPER COOLER WITH COPPER TUYERE IN POSITION

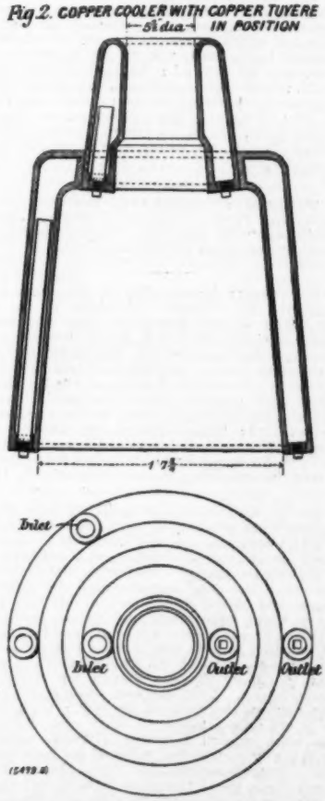
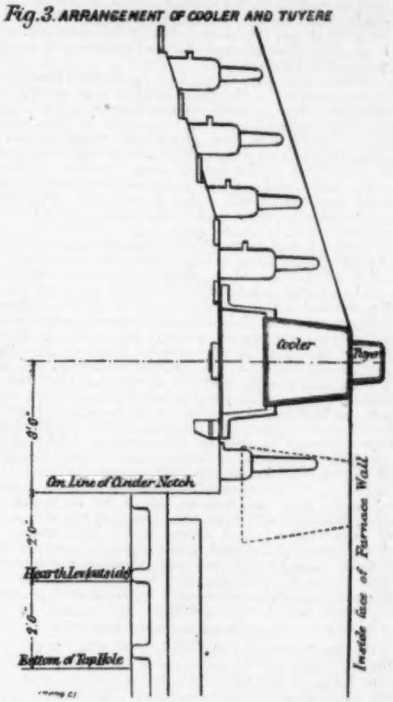


Fig. 3. ARRANGEMENT OF COOLER AND TUYERE



The copper tuyere is generally used in conjunction with a copper cooler of somewhat similar shape and design to the tuyere. The cooler is set rigidly in the brickwork of the furnace wall, extending to its inner edge only, and is of such size that most of the tuyere passes through the cooler, the outer and larger portion of the tuyere making a joint about 3 in. long with a corresponding inner portion of the cooler. The purpose of the cooler is to form a cooling protection for the brickwork about the tuyere arch, and to provide a rigid seat for holding the tuyere in place and keeping it at a fixed position in relation to the inner edge of the furnace wall and the centre of the furnace; also to ensure ease of removal and to do away with the use of the clay packing usually necessary where cast-iron tuyeres are used. Fig. 2 shows the arrangement in section.

At first sight the equipping of a blast furnace with copper coolers and tuyeres seems to be an expensive arrangement compared with the old cast-iron tuyere arrangement, and in first cost this is undoubtedly so. But in blast-furnace construction first cost must not be given too great consideration if economical results are to be obtained, and there are certain advantageous features in connection with the use of copper tuyeres, as compared with cast-iron tuyeres, which fully warrant the greater first cost.

First, they are much more durable, they are much more quickly and less laboriously removed and replaced, and they form a much neater and more mechanical job.

Secondly, there are certain serious disadvantages having an important bearing upon blast-furnace results, arising out of the use of cast-iron tuyeres, which are entirely removed by the use of copper tuyeres.

It is very important in a blast furnace designed for a certain diameter of hearth, that the extension of the tuyeres inside the furnace walls should be constant and the same for each tuyere. The diameter at the tuyeres, *i.e.*, the distance from the nose of a tuyere on one side to the nose of the tuyere exactly opposite, is the real hearth diameter, as the horizontal area inside the tuyere noses represents the grate of the furnace, and the amount of fuel to be burned is in proportion to the cubic feet of blast blown per minute and the area of the hearth or grate of the furnace. The furnace manager determines by experience, and perhaps by experiment, when necessary, the size of tuyere most suitable for any particular furnace conditions, this size depending upon the quantity and normal pressure of the blast, the number of tuyeres, and the extension of tuyeres inside the furnace walls, this extension varying, according to the conditions under which the furnace is being operated, from 6 in. to 15 in. Having determined the most suitable extension of the tuyeres, that extension must be regularly maintained, otherwise the destruction of the furnace walls will take place through lack of sufficient penetration of the blast into the centre of the furnace, or certain disturbances will occur dependent upon uneven blast distribution.

With cast-iron tuyeres, when a tuyere burns or cracks

* Paper read before the Iron and Steel Institute on Thursday, May 2, 1918.

and water runs into the furnace, the water must be turned off at once to avoid chilling the furnace hearth, and when the water is turned off, the tuyere immediately melts away, and the furnace is run with the nose of that tuyere right back to the furnace wall. As it is not necessary to remove the tuyere at once, the water being turned off, there is also a tendency for the men or foreman to wait for a convenient time before taking the stub of the burnt tuyere out and replacing it with a new one with the proper extension. During this time the furnace is working lopsided, and a strong tendency to irregular working established.

With copper tuyeres no such haphazard practice can be indulged in, for the water must be kept on the tuyere until the blast is taken off the furnace and the tuyere removed from the cooler, because if it were not the tuyere would burn back, the copper would be lost, and incandescent fuel would blow out through the burned tuyere. The copper tuyere must, therefore, either be taken out at once, or the water slacked down, to minimise the leak, until cinder is run out. The proper extension of the tuyere inside the furnace wall is therefore maintained at all times.

Until a few years previous to the outbreak of the war, copper tuyeres were always made of cast copper, and owing to the lack of homogeneity in such metal after a few months' cracks would occur in the nose through its wearing away by the abrasion of the materials passing over it. This difficulty was entirely overcome by making tuyeres of rolled, hammered, or pressed copper (see Fig. 1, with brazed joint at X). These tuyeres are known as forged copper tuyeres, and were, I believe, originally made in Germany. They are very homogeneous and frequently lasted from nine to twelve months, and in one case I know of, for eighteen months, in continuous use. This question of the manufacture of forged copper tuyeres in this country is one of considerable importance as bearing directly upon the saving of copper, and in the cost for tuyeres per ton of iron produced, besides ensuring much less frequent leakages of water into the furnace. It is to be hoped that manufacturers will take this question up with a view of producing a forged copper tuyere comparable with those formerly obtained from Germany, and that blast-furnace managers will encourage those who undertake to make them by adopting that type of tuyere, with all the accompanying advantages to themselves in connection with their furnace practice.

CANET LECTURE.—Sir Wilfrid Stokes, K.B.E., has kindly consented to deliver the third Canet Lecture. His discourse will have reference to the gun with which his name is so closely associated. The lecture will be delivered on Monday evening, June 24, at 7.30, in the Lecture Room of the Royal Society of Arts, John-street, Adelphi. Exhibits and a selection of slides are to be expected.

THE LATE MAJOR ALGERNON G. PARSONS.—We greatly regret that Major A. G. Parsons, R.F.A., the only son of the Hon. Sir Charles A. Parsons, K.C.B., was killed in action on April 26 last, as there is thus cut short a career which gave promise of being brilliant and of advantage to engineering. Major Parsons was born in 1886, and was educated at Eton and Woolwich, his ambition, for a time, being to enter the Army. He took his commission in 1906, but only served for three years, entering then the engineering profession. He advanced steadily in his father's works, becoming ultimately a director of Messrs. C. A. Parsons and Co., of Heaton. There he showed not only the hereditary qualities of inventive ingenuity, but marked administrative ability. At the outbreak of war he rejoined the Royal Field Artillery, and went to the front in November, 1914. The aeroplane had always attractions for him, and long before the war he tackled some of the problems from the experimental point of view, so that when it was realised that the aeroplane was going to play a great part in the war, Major Parsons was appointed to the Experimental Department of the Royal Flying Corps, and was instrumental in effecting several useful improvements in this new weapon of warfare. In November, 1917, Major Parsons was wounded in the fighting near Cambrai, and returned to the command of his battery early last month, only a few weeks later to make the supreme sacrifice.

LORD KITCHENER SCHOLARSHIPS.—The scholarships will enable officers and men of the Navy and Army, and their sons, to undertake a complete course of industrial and commercial education at any university or similar approved institution. But the Kitchener scholarship may not be held with any other scholarship, and the committee on making their selection of students will have regard to (*a*) evidence of exceptional ability, (*b*) submission by the candidate of a well-thought-out plan of training, and (*c*) the possession of a suitable minimum of scholarship preparation. The plan of training will include both works experience and college education. The former may be one, two or three years in works between school and college or concurrent with college education. Industrial or commercial education may include a three years' course in industrial art. Candidates must submit to the Lord Kitchener National Memorial Fund, at 34, Norfolk-street, London, W.C. 2, with their application a record of school career, a recommendation by the principal of school, or if engaged in industry or commerce a recommendation from employer. A statement as to financial circumstances should be attached showing amount of assistance desired. The scholarship will not in any year exceed 175*l.*, plus tuition fees, but in cases of students studying abroad approved travelling expenses may be added. The committee are prepared to assist officers and men to complete any course of training they have already begun.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Engineers' Small Tools.—A recent order with respect to engineers' small tools states that no longer may Class A certificates be used when buying small tools, even if they are to be employed in connection with the production of a direct Government contract. Such a certificate is only to be given when the goods are to become a component part of the contract; otherwise, only a Class B certificate may be given.

Iron and Steel.—It is almost impossible to detect any variation in trade conditions. Makers of steel for shipbuilding and aircraft continue to be hard pressed for deliveries, and there is a prospect of these two departments being kept feverishly busy for a considerable time ahead. On the other hand, quietness continues to mark the calls that are being made for steel required either directly or indirectly for the manufacture of shells. The slackened demands in this direction have left a good deal of plant in smaller engineering concerns idle. Had the Government been able to see their way to relax the export restrictions it would have facilitated a good deal of work in these places for overseas destinations; but as conditions exist to-day, while there is apparently no obstacle in the way of firms gaining permission to manufacture goods for overseas, they are afforded few chances of getting their products actually exported, with the result that lots of steel and tools are lying in warehouses where they must remain until the highly uncertain export licence is forthcoming. A local firm is concentrating on the production of iron bars to be used as a substitute for the Swedish brand. Along with other substitutes for the Swedish products which are being turned out in this country, it is reported to serve very well for high-speed steel. But all these home attempts to replace the Swedish iron, coming as they do when conditions do not permit of extensive imports of iron and steel from Swedon, should prove highly acceptable. Tool steel is being called for in great volume, and in some of the rolling mills there is great activity on steel bars to be used in connection with reinforced concrete.

South Yorkshire Coal Trade.—The coal position becomes more anxious week by week. On to a considerably diminished output is being crowded a very heavy demand for manufacturing fuels. Indeed, so voluminous have become the calls for the latter that the house coal supply has been drawn upon, but even with this augmentation it is exceedingly difficult to appease the calls from manufacturing centres. Exports do not alter in amount and Government requirements continue to account for a preponderance of tonnage. Gas fuels are actively sought, notwithstanding the operation of summer-time, the heavy demand being due to the extensive use of gas for industrial purposes. There is a big demand for slacks, but in this department, as in others, the supply is not anything like adequate. Prices remain at the maximum figures. Quotations:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* to 14*s.* 6*d.*; seconds, 13*s.* to 13*s.* 6*d.*; smalls, 9*s.* to 10*s.*, per ton at the pit.

THE TEACHING OF PHYSICS IN SCHOOLS.—At the meeting of the Physical Society on Friday, June 14, a discussion on "The Teaching of Physics in Schools" will be introduced by Sir Oliver Lodge.

THE COMMERCIAL MOTOR USERS' ASSOCIATION (INCORPORATED).—The General Committee of the Commercial Motor Users' Association has unanimously decided to nominate Colonel R. E. B. Crompton, C.B., who has been chairman of the association for nearly fifteen years, as its first president. A general meeting of members will be held in London on the 31st inst. to inaugurate the president and vice-presidents, and Colonel Crompton has consented to deliver a presidential address entitled: "The Future of Heavy Motor Transport." The new chairman of the committee will be Mr. E. S. Shrapnell-Smith, who has been honorary treasurer of the association since its formation in 1903.

SALVAGE IN THE ARMY.—Salvage is the term adopted to designate what is known as prevention of waste and recovery of waste products and materials in any well-conducted manufacturing concern, and becomes of paramount importance during a war, when the State is at the same time the chief manufacturer and consumer. Newspapers and official reports have of late been full of complaints about gross waste and serious loss arising from inefficient management and control, and it is all the more satisfactory to note that there is a Department of National Salvage, of which Mr. David Currie is director, and that the Army Salvage Branch can claim some noteworthy results. From kitchen refuse glycerine has been extracted to the value of 500,000*l.*; the proceeds of sales of old boots, useless for army wear, but fit for civilians after repair, represent 170,000*l.* annually; and the raw woollen material obtained per year from old garments represents nearly 1,000,000*l.* These and other savings are due to the co-operation of the Supply Department, under the Surveyor-General of Supply, Mr. Andrew Weir, and of the War Office and the Ministry of Munitions, and the savings mean also relief to existing manufactories, a diminution of imports, and relief to shipping, rail and road transport. A Salvage Club has been founded, the organ of which made its first appearance on April 1, 1918, under the title *Salvage*.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There has been much activity in Cleveland pig-iron, of late, so far as home business is concerned, but there is something of a lull now, the bulk of this month's buying, under the liberal allocations, having been completed, and traders are now busy arranging deliveries which promise to be on a heavy scale, as the truck supply is considerably better, and is still steadily improving. At the same time, whilst there is distinctly less congestion on the railways, the wagons available are still a good deal short of sufficient to satisfy full demands of customers, and effort is being made to ship iron to Scotland, Wales and Ireland in small coasting steamers so as further to relieve pressure on the railways, notwithstanding that freights are high in comparison with rail rates. Cost, however, has become quite a secondary consideration, and many consumers are quite willing to pay high charges in order to get their needs supplied. A fairly good business in forge iron has been put through. This quality does not come under the monthly allocation system, and buyers show a desire to make contracts three months ahead, but makers are not disposed to commit themselves forward to any extent. Export trade with France is proceeding regularly. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge are all quoted 95*s.*, and No. 1 is 99*s.*; and for shipment to France and Italy, No. 3 and the lower qualities are 114*s.*, and No. 1 is 119*s.*

Hematite Iron.—Slackness in export trade in hematite is to the advantage of home customers who are getting ample supplies from current output. Mixed Nos. are 122*s.* 6*d.* for home use, and 147*s.* 6*d.* for export to France and Italy.

Manufactured Iron and Steel.—The huge output of finished iron and steel is promptly absorbed. The new system of distribution is working satisfactorily, and it is gratifying to learn that shipbuilding orders having been overtaken, it is possible to pay more attention to other work, though Government needs continue such as to leave little opportunity for ordinary commercial business. Common iron bars are 13*l.* 17*s.* 6*d.*; best bars, 14*l.* 5*s.*; best best bars, 14*l.* 12*s.* 6*d.*; iron ship plate, 15*l.* 10*s.*; iron ship angles, 13*l.* 17*s.* 6*d.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.* The foregoing quotations are for home purposes. There are no fixed prices for export, but approximately they may be given at 2*l.* to 3*l.* above the home quotations.

AIRCRAFT PRODUCTION.—The Minister of Munitions has appointed Sir Arthur Duckham, K.C.B., to superintend as Member of Munitions Council, the duties of Aircraft Production in succession to Sir William Weir on the latter's appointment as Secretary of State and President of the Air Council.

ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN.—The mid-year conference of the Representative Council, consisting of delegates from the branches in Great Britain and Ireland, met on Saturday and Sunday, May 4 and 5, in Newcastle. A scheme was agreed upon whereby the Association is now divided up into 25 districts, consisting of 70 sub-branches. It was arranged that Leeds will be the meeting place for the Annual Conference of this Council to be held in December next.

ORDER CONCERNING MACHINE TOOLS.—The Ministry of Munitions states that power-driven machine tools or woodworking machines and treadle lathes for woodworking or metal (3-in. centres and over) come under Regulation 30A of the Defence of the Realm Regulations, and intending purchasers must make application for permission to purchase the machines they require to the executive officer of the Area Clearing House Board in their district. Firms (including auctioneers) must obtain permission to sell machines from the Controller of Machine Tools, Charing Cross Buildings, Embankment, W.C. 2.

THE ROYAL INSTITUTION.—A general meeting of the members of the Royal Institution was held on the 6th inst., Sir James Crichton-Browne, M.D., F.R.S., treasurer, in the chair. The following Vice-Presidents were elected:—Henry E. Armstrong, LL.D., F.R.S.; Sir Wm. Phipson Beale, Bart., K.C., M.P.; the Hon. R. C. Parsons, M.A., M.Inst.C.E.; the Right Hon. Lord Rothschild, F.R.S.; the Right Hon. Lord Wrenbury, P.C., M.A.; Sir Charles Nicholson; Sir James Crichton-Browne, M.D., F.R.S., Treasurer; Colonel E. H. Hills, C.M.G., R.E., F.R.S., Secretary. Sir George Stuart Forbes, George H. Heard and Lieut.-Colonel C. S. Myers were elected members.

THE PRESERVATION OF BUILDING STONE.—In a paper contributed last December to the Glasgow section of the Society of Chemical Industry, Dr. C. H. Desch reports very favourably on the use of soluble silico fluorides for the preservation of building stone. The method was, he states, first described by Kessler in the *Comptes Rendus* for 1883, and has been largely adopted in France. The double salt of aluminium and zinc is, he states generally used. In the reaction with calcium carbonate insoluble compounds are formed. Highly porous limestones can therefore be rendered much more impervious by impregnation with these salts and their resistance to weathering greatly enhanced. The salts and compounds produced are colourless, so that the appearance of the stone treated is not changed.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The intense activity in the steel-making industry in the Glasgow area is an oft-told tale now, yet as vital a force in the industrial world to-day as at any period since the outbreak of war. Manufacturers are making the best possible use of every available source of production with highly successful result because, although it is not feasible to avoid the accumulation of a certain percentage of arrears, it is truly amazing that, under the very strenuous conditions under which all work is carried out, matters have proceeded so smoothly. Demands from the shipbuilding yards for parts of all kinds—plates, sections, &c.—are still very great, and prompt delivery for work of this description is an absolute necessity. It means a hard task for masters and men alike. Naturally, the home requirements of our own Government for work of national importance have first claim and after these are satisfied to an extent, a certain proportion of the available output is permitted for shipment to meet the more urgent necessities of the French Government. A call has also been made on behalf of the Indian State Railways; and, while it is quite apparent that this cannot be lightly passed over, the supply at disposal is limited in the extreme.

Malleable Iron Trade.—The malleable iron trade continues to flourish, if the expression might be applied to the feverish conditions which exist in every establishment doing Government work, and all practically come under this category. Government's demands are absolutely insatiable, and the entire tonnage, both of the iron and the steel departments, goes direct for purposes of the war. This makes it impossible for makers to spare any of their output for export.

Scotch Pig-Iron Trade.—Although the supply of pig-iron falls short, in a measure, of the heavy demand, the present scheme of distribution works well, and large numbers of customers now share in the production. No stock can be accumulated, of course, for the whole output goes direct from the smelter to the consumer, and all is absorbed for home use, little or nothing being available for export. Prices still remain strong, no change having taken place.

THE TROLLHÄTTA CANAL.—The Trollhätta Canal-Vänern traffic has entered upon a new phase after the reconstruction of the canal. Whilst formerly it generally had to be suspended some four months on account of frost, it is now thought practical to continue the traffic during winter by the aid of a strong ice-breaker and more powerful vessels and tug boats. The Swedish Waterfalls Board recommend an ice-breaker of 600 h.p. to 800 h.p., of which the State should pay half the cost and the rest be defrayed by towns, shipping and other concerns, particularly interested in the question.

AUTOMOBILES USED FOR DRIVING MACHINERY.—An illustration is published in *Machinery*, New York, showing a machine shop in which three automobile chassis were used to drive the line shafting which runs the machinery, the electric power company having had to shut down for a time owing to lack of coal. The automobile chassis were mounted on blocks and the rear wheels were replaced by pulleys belted up to the line shaft. Not only was all the machinery run very satisfactorily by this method for several weeks, but power was furnished to an air compressor and elevators.

WATER POWER IN THE UNITED STATES.—We read in *Machinery*, New York, that the stationary power plants of the United States generate 49,000,000 h.p., and use 30 per cent. of all the coal mined in the country. Mr. Lane, Secretary of the Interior, has estimated that 35,000,000 h.p. may be obtained from the nation's wasted water power; only 6,000,000 h.p. is now being generated hydraulically. In other words, should the country's wealth of water power be fully developed, more than two-thirds of the fuel now used to generate power—a total of 139,000,000 tons—would be saved. Not only that, but 380,000 men now required for mining, transporting and firing this coal would be released for other work, only 40,000 men being required for the hydraulic plants. Nearly 200,000 railway wagons and 5,000 locomotives would be set free. Granting to private interests the right to develop national water power upon terms that are fair to all concerned, adds our contemporary, is one of the most important among the industrial problems that now demand solution, since it affects materially the question of saving of coal.

MANUFACTURE AND REPAIR OF RIFLES, PISTOLS, REVOLVERS AND SHOT GUNS.—The Minister of Munitions has ordered that: (1) As from May 15, 1918, until further notice, no work shall, except under a licence issued under the authority of the Minister of Munitions be carried on in any factory, workshop or other premises on or in connection with the manufacture or repair of any rifle, pistol, revolver or shot gun, or any part of a rifle, pistol, revolver or shot gun. (2) The Order of the Minister of Munitions of May 11, 1917, as to the manufacture and repair of sporting guns and rifles is hereby cancelled as from May 15, 1918, but such cancellation shall not affect the previous operation of the said order or the validity of any action taken thereunder or the liability to any penalty or punishment in respect of any contravention or failure to comply with the said Order prior to its cancellation, or any proceeding or remedy in respect of such penalty or punishment. (3) All applications for a licence in connection with this Order shall be made to the Controller of Small Arms and Machine Gun Supply, Ministry of Munitions, Whitehall-place, London, S.W. 1.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—The pressure, particularly on Admiralty collieries, continues, and of all the better qualities of large coal there is still an appreciable shortage. For private account, indeed, hardly any is being released, and the stringency of the market in this respect is likely to continue. Italy is receiving larger quantities, and it is understood that the conditions governing these exports bring them financially within the scope of the pooling scheme. Bituminous coals are relatively scarce, the usual falling-off about this time of the cold weather demand being counteracted by orders for storage purposes for next winter in view of the possibility of the application of the rationing system to coals for house and inland industrial consumption. Production is naturally suffering from the comb-out of workmen for military service, and it is anticipated, it will still further suffer. Meanwhile the demand shows no sign of falling off; on the contrary, it is quite as active as it has been at any time during the past four or five weeks. Some of the inferior steam smalls, however, are not so scarce as they have been, but outputs are falling-off, and for coking descriptions there is still a shortage. There are fair supplies of pitwood and iron ores.

Newport.—There is no diminution in the volume of business in Monmouthshire coals. The demand for Eastern and Western Valley coals is fully maintained while best Black Veins are scarce. The only signs of easiness in the small-coal market are those affecting some of the cheaper bituminous smalls, but smalls generally are in good demand in connection with new Allied orders. It is now reported that the negotiations over the zone scheme for the supplies of coal to the South-Western Counties have now been practically completed.

Miners for the Army.—The combing-out of miners for the Army proceeds very satisfactorily from the point of view of the recruiting authorities in the South Wales coalfield. There were a few who endeavoured to create trouble, but these extremists have, for the time being, at any rate, been given their quietus, and thousands of men are enlisting without waiting to be called up. The first quota has been completed, and during the present month 6,000 more will be required, but no difficulty is anticipated, and at a joint meeting of representatives of the National Service, of the coalowners, and of the workmen, held on Tuesday, the final arrangements were completed, and instructions embodying these have been sent to the collieries and to the miners' lodges.

Coal Exporters' Brokerage Issue.—A meeting of local coal exporters was held on 'Change last Thursday, further consideration was given to the Order of the coal Controller depriving exporters of their usual one-third of 5 per cent. brokerage. It is now generally known that in the opinion of counsel the Order is invalid, but after reviewing the situation generally, the exporters decided to defer taking legal action for the recovery of the brokerage pending a further effort to obtain from the Coal Controller some favourable terms by negotiation.

Industrial Councils for Patent Fuel Industry.—At a joint meeting of representatives of the employers and workmen of the patent fuel industry of South Wales, held at the Conference Hall, of the Cardiff Chamber of Commerce last Friday, under the presidency of Mr. E. J. P. Benn, of the Ministry of Reconstruction, it was agreed to form an interim committee comprising four representatives of manufacturers and workmen respectively with a view to another meeting being held for the purpose of setting up an Industrial Reconstruction Committee for the industry.

AMENDING THE GLASS CONTROL (CONSOLIDATED) ORDER, 1917.—As from May 7, the Glass Control (Consolidated) Order, 1917, shall be read and take effect as if in Clause 8 of that Order the words "and the expression 'electric lamp glass' shall include all glass used or intended for use in the manufacture of electric lamps, not excepting vitrite or other glass used or intended for use in electric lamp caps for insulating purposes, but shall not include glass shades and similar accessories" were substituted for the words "and the expression 'electric lamp glass' shall include all glass used or intended for use in the manufacture of electric lamps, except glass used or intended for use in lamp caps for insulating purposes, but shall not include glass shades and similar accessories." All applications in reference to the above Order should be made to the Controller of Glassware Supply, Ministry of Munitions of War, 22-23, Hertford-street, London, W. 1.

INVENTIONS FOR DISABLED MEN.—The Inventions Department of the Ministry of Munitions, in conjunction with the Ministry of Pensions, is actively investigating improvements of appliances for men who have lost limbs. The immediate object is to devise or adapt to the artificial arm hand tools of the various crafts that will enable the men to carry on their previous trades as plumbers, blacksmiths, carpenters, and so on. It is hoped that the men may acquire facility in their use equal to the skill of the hand, in so far as guidance and pressure is concerned. Investigations with a view to selecting the best materials of manufacture of artificial legs and cheapening their production are also proceeding. The four problems before the department are: (*a*) Investigation of inventions; (*b*) adaption of tools; (*c*) determination of the most suitable materials for construction; and (*d*) devising the best machinery, and its application towards cheapening and increasing rapidity of production.

NOTICES OF MEETINGS.

THE PHYSICAL SOCIETY OF LONDON.—Friday, May 10, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, S.W. Agenda: 1. "On the Times of Sudden Commencement of Magnetic Storms," by Dr. S. Chapman; 2. "The Entropy of a Metal," by Dr. H. S. Allen, M.A.; "On Tracing Rays Through an Optical System," by Mr. T. Smith, B.A.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Friday, May 10, at 6.30 p.m., at the works of Messrs. D. Napier and Sons, at Acton, a paper on "An Examination into the Causes of Failure of Lorry Parts," by Lieutenant-Colonel Bagnell-Wild, and a paper on "Tank Engines," by Mr. Geo. W. Watson. All young men being trained for the profession of automobile engineering are invited to apply for tickets to the Secretary, at 28, Victoria-street, S.W. 1.

THE LONDON ASSOCIATION OF FOREMEN ENGINEERS.—Saturday, May 11, at 6 p.m., at the Cannon Street Hotel, London, E.C. Sixty-fifth Anniversary Festival. Chairman, Sir Hugh Bell, Bart.

THE ROYAL SOCIETY OF ARTS.—Monday, May 13, at 4.30 p.m.: Cobb Lecture, "Recent Developments in Leather Chemistry," by Mr. Henry R. Procter, D.Sc., F.I.C., Emeritus Professor of the Chemistry of Leather Manufacture, Leeds University, Director of the Procter International Research Laboratory (Lecture I). Tuesday, May 14, at 4.30 p.m.: Cobb Lecture, "Recent Developments in Leather Chemistry," by Mr. Henry R. Procter, D.Sc., F.I.C., Emeritus Professor of the Chemistry of Leather Manufacture, Leeds University, Director of the Procter International Research Laboratory (Lecture II). Wednesday, May 15, at 4.30 p.m.: Ordinary meeting, "The Timber Industry," by Mr. Percy Groom, M.A., D.Sc., F.L.S., Professor of Technology of Woods and Fibres, Imperial College of Science and Technology. Thursday, May 16, at 4.30 p.m.: Special Lecture, "The Freedom of the Sea, by Mr. John Leyland. Lecture III: The German "Freedom of the Seas." Admiral Sir Edmond John Warre Slade, K.C.I.E., K.C.V.O., R.N., will preside.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, May 14, at 6.30 p.m., at the Royal Society of Arts, John-street, Adelphi, London, a discussion on "The Lighting, Heating and Power Order (1918), and the Best Methods of Making Economies."

THE CERAMIC SOCIETY.—Tuesday and Wednesday, May 14 and 15, in the Mappin Hall of the Sheffield University, St. George's-square, Sheffield. The president, Mr. W. J. Jones, Deputy-Controller of Iron and Steel Production, Ministry of Munitions, London, will preside. On Tuesday, May 14, the following papers will be read at the morning meeting, commencing at 10.30 a.m.: "The Supplies of Refractory Materials Available in the Sheffield District," by Professor W. G. Fearnsides; "Notes on the Evolution of the Ganister Industry in the Sheffield District," by Mr. J. Holland; "The Constitution of Silica Bricks," also "A Micro-Study of Magnesite Bricks," by Dr. A. Scott; "The Essential Properties of Refractories Used in Steel Production," by Mr. Alleyne Reynolds; "An Advance towards Greater Economy of Fuel and Increased Output in the Deadburning of Magnesite and Dolomite and the Burning of Cement," by Mr. E. Steiger. The following papers will be read in the afternoon, commencing at 3 p.m.: "Silica Refractories and the Materials Used in their Manufacture," by Professor A. Bigot; "On Refractory Materials Derived from Bauxite (Fused and Crystalline)," by Professor A. Bigot; "The Dissociation of Salt," by Mr. H. V. Thompson; "Refractories in Gas Works from a User's Point of View," by Mr. J. P. Leather. On Wednesday, May 15, the following papers will be read at 10.30 a.m.: "First Report of Committee on the Standardisation of Methods of Testing," presented to the Secretary by Dr. J. W. Mellor; "Note on Electric Furnace Treatment of Refractories," by Dr. R. S. Hutton; "A Note on a Firebrick from the Crown of an Electric Steel Furnace," by Mr. W. J. Rees. At 6.30 p.m. an evening lecture, open to the public, on "Science and the Practical Man," will be delivered by Mr. Cosmo Johns. A number of works will be visited on Wednesday afternoon.

THE JUNIOR INSTITUTION OF ENGINEERS: NORTH-EASTERN SECTION.—Tuesday, May 14, at 7.15 p.m., at the Mining Institute, Neville-street, Newcastle-on-Tyne. Paper on "Stores Organisation," by Mr. E. F. Oakford.

THE SOCIETY OF GLASS TECHNOLOGY.—Wednesday, May 15, at London:—10.15 a.m.: Visit to the works of Messrs. Ediswan Electric Company, Limited, Ponder's End, Middlesex, at the kind invitation of the directors. 2.30 p.m. meeting in the Rooms of the Institute of Chemistry, Russell-square, W.C. 2: A paper will be read by Mr. A. R. Hunter, on "Furnace and Factory Operation for Automatic Glass Working Machinery." 3.30 p.m.: The President, Mr. W. F. J. Wood, B.Sc., F.I.C., will initiate a discussion on "The Glass Industry after the War."

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, May 15, at 5 p.m., at 70, Victoria-street, Westminster. Papers to be read: 1. Continentality on Temperature, second paper, "The Effect of Latitude on the Influence of Continentality on Temperature," by C. E. P. Brooks, M.Sc., F.R.Met.Soc., F.G.S.; 2. "Report on the Phenological Observations for 1917," by Mr. J. E. Clarke, B.Sc., and Mr. H. B. Adames.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, May 17, at 39, Victoria-street, Westminster, a lecturette by Mr. J. Fisher, on "The Vertical Retorts at Tottenham Gas Works." Saturday, May 18, at 3.15 p.m., a visit to the new retort houses and works in Willoughby-lane, Tottenham, of the Tottenham District Heat, Light and Power Company. Train leaves Liverpool-street at 2.52

THE JURASSIC IRONSTONES OF THE UNITED KINGDOM.

(*For Description, see Page* 514.)

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No. 3. FRODINGHAM IRONSTONE MINES, NORTH LINCOLNSHIRE. TRANSPORTER, WITH TRAVELLING SKIP FOR DUMPING COVER REMOVED BY "NAVVY."

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TELEPHONE NUMBERS—3663 and 8596 GERRARD.

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NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 519.

ENGINEERING.

FRIDAY, MAY 10, 1918.

THE EFFICIENCY OF LABOUR.

ON another page we report the discussion which took place last Friday, the 3rd inst., on Mr. Ben H. Morgan's paper read before the Institution of Mechanical Engineers. Unfortunately nearly all the speakers confined themselves to discussing the capacity and limitations of women as munition workers, and entirely ignored the broader aspect of the paper, which implicitly dealt with the means of increasing the capacity and reducing the limitations of works owners and managers. After detailing his scheme, Mr. Morgan said in conclusion: "This would have a lasting effect on British industry after the war by helping to establish standards of output, standard methods of subdividing work, and the adoption of such plans as would give the best results in the various branches of engineering industry. Thus . . . it could help the country to preserve for the benefit of British industry the dearly-purchased experience gained in the struggle through which we are passing." A project that held forth such a promise would have commanded, one would have thought, the fullest attention from a gathering of engineers, and have evoked either commendation or criticism. It is not a case in which silence can be construed to mean consent, for Mr. Morgan has been struggling against inertia, ridicule and opposition for more than two years, and even to-day, with a powerful Ministry behind him, he often finds his path obstructed. For the moment we are not considering his immediate objects, the increase in the output of munitions and the allocation of skilled men to skilled jobs, but rather the effect of his methods on our position after the war, when we shall have to meet the competition of the world.

The outstanding feature in the manufacture of munitions is the wonderful increase of output obtained by women on repetition work, as compared with that previously got from skilled men. The former condition of affairs was partly due to the union policy of restriction of output, but it was also attributable to the fact that large numbers of engineers fail woefully as manufacturers. When it is found that women can bore two and a half times as many shells in a week as skilled men did formerly, it is clear that the management was at fault, for no one would consciously be content with only two-fifths of a possible output. Neither would it be accepted as reasonable to pay skilled rates of pay for work that can be done perfectly after a few weeks' training, if the conditions were realised. The war has taught us much, and one of its most valuable lessons has been its demonstration of the failure of the ordinary engineer as a manufacturer. The lesson, however, is far from complete. There are still hundreds of works in which it has not been properly learned, and in which inadequate methods are still clung to in spite both of precept and example. It is Mr. Morgan's object to put an end to this state of affairs by the compilation of records of the times taken in all operations on munitions, so that every works manager may see how far he is deficient in attaining a good standard of efficiency, either from want of the right kind of tools or from bad distribution of work, or inadequate supervision. We have now an opportunity, such as we trust will never occur again, of tuning up our engineering works in the way of scientific management. The same article is made in a dozen or a hundred places; the methods followed are numerous, the tools are often diverse and the times occupied are various. Yet the final products are of equal merit since they have to pass rigid inspection, and the efficiencies of the methods and tools can be expressed in terms of labour-hours. Here is a splendid opportunity of making researches in scientific management on a large scale and the opportunity ought to be welcomed. The occasion is unique in that commercial competition is almost extinct. There are orders to be had for the asking, while profit-making is rigidly curtailed by taxation. No one need shrink from having his methods published, even if he has not yet learned the lesson that national prosperity affords the best occasion of individual good, and that unless we succeed as a whole in the future we shall have a poor chance individually. While Mr. Morgan's efforts are directed to the present task of both finding ample labour for munition making, and of releasing men for the army, they should have the ultimate effect of working a revolution in our workshop methods by accumulating a vast collection of data from which it will be possible to decide the cheapest and most efficient method of carrying out in the future any job which lends itself to repetition work.

Turning now to Mr. Morgan's immediate object—the most efficient present utilisation of labour in engineering factories—we may explain that he proposes to ration the available labour supply as fairly as possible among manufacturing undertakings, allotting labour, both as regards quantity and quality in accordance with the efficiency with which it is utilised. Logically, the proposition is incontestible. From the national point of view labour must be employed where it is most productive, and individual undertakings must not be permitted to absorb man-power unless they are so managed and equipped that the nation gets the fullest return from the labour-hours consumed. This general principle being admitted, the first practical step towards giving it effect consists in deciding upon criteria by which the efficiency of the utilisation of labour may be gauged. Standards of production have to be set up for all important munitions work from aeroplane engines to standard ships, and the labour-hours necessary for a given output decided upon. This work involves a consideration of the most efficient methods of manufacture, and incidentally it also indicates in some measure a fair price to be paid for the product. Had the Government proceeded along such lines heretofore it would have been able to save enormous sums of money and a vast amount of needless labour, while by being in a position to avoid entering into the deplorable system of "time and line" contracts, many of the recent financial scandals would have been avoided.

On the other hand, those firms which were efficiently organised for production would have been automatically brought to the notice of the Contracts Department and would have had a right to preference with regard, not only to renewal of contracts, but to such supplies of material, labour, machinery, &c., as they might require. Virtue would have entailed substantial advantages, instead of being, as at present, its own and only reward.

Mr. Morgan's proposal with regard to dilution is in line with the policy he advocates in connection with labour supply generally. He suggests that, not only should a standard number of labour-hours be established for a given output, but that a further standard of dilution should be insisted upon in connection with each particular kind of product. For example, a firm undertaking a contract for aeroplanes of a certain type would be expected to deliver them at the rate of, say, one per week for every 100 hands on the pay roll, and of their employees a minimum of, say, 50 per cent. must

be women or discharged soldiers. Such conditions embodied in a contract would keep definitely before the contractors the standards expected of them, and provide a continual check upon the efficiency of their organisation and manufacturing methods. So far as standards of dilution are concerned, these have been enforced for some time in factories manufacturing the smaller sizes of shell, and in spite of the enormously wide range of conditions and the variety of the machinery in use, they have been attained practically universally. The contrast between the equality of labour conditions attained in connection with shell below 6 in. diameter, and the confusion and heartburning which arises out of the variety of dilution effected on larger shells and other products, is sufficient to prove the benefit of some dilution standard being enforced. The present situation with regard to dilution cannot be allowed to continue and should give way to a fair and firm enforcement of equal conditions throughout the engineering industry. The extent to which it is necessary or advisable to carry out dilution in any trade should be determined by the department of the Government responsible for the man-power of the country, and its considered decisions should not be thwarted by any political opportunism at so grave a crisis in the affairs of the nation.

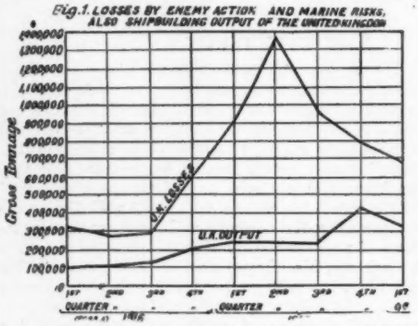
An indirect effect of the establishment of such standards would be, as we have already indicated, that munition contracts would tend to be placed with such firms as are best fitted to carry them out. We should be spared the irritation of seeing shipping occupied by the importation of agricultural machinery while our implement makers are busy making shells, and firms specially equipped for shell manufacture are having their contracts reduced. We should not find little contracts for which it would hardly pay to make jigs or devise fixtures, placed here, there and everywhere, instead of being awarded in bulk to such firms as were in a position to complete them with the minimum expenditure of labour both on the contract itself and upon the tools, jigs and gauges necessary for cheap production. In fact, as regards the tools and gauges themselves, these, under a good munitions system, would be produced by repetition processes in special factories at a price with which no ordinary tool-room could compete, and the highly skilled mechanics now occupied in making them one by one in private tool-rooms could be released for work for which they are needed and which is of vastly greater value to the empire.

If such a plan as this were adopted all through the country it would allay the feeling of irritation suggested by Sir Herbert Austin in the discussion, and patriotic manufacturers would no longer harbour the suspicion that their sacrifices were being exploited by their neighbours. It would further help immensely in winning the war, as it would release many young men and not leave us dependent on those whose fighting days are really ended. But in addition to the direct gain there would be a by-product of enormous value in that we should have made a very great advance in the art of manufacturing. Every works manager would have undergone an intensive period of education, and would see his daily work from a new point of view. We already have an example of this state of affairs in our electric light stations. When these were first inaugurated the Board of Trade got out a standard method of keeping accounts which was made obligatory on them all. The result is that the expenses of every station can now be compared, point by point, with those of every other station, and each source of leakage and waste traced and detected. It is not possible for a manager to live a slack life, and to beguile his superiors with excuses, for they can set his figures side by side with those of stations of similar size and output. It is impossible to arrive at such an exact result in engineering matters, but if we had the great accumulation of data which Mr. Morgan proposes, it would no longer be feasible for a works to be run at an efficiency of 40 per cent. But far beyond the value of the figures would be the new atmosphere and attitude of mind which would be created. A condition of "divine discontent" would be engendered which would continually impel managers to seek for new methods and better appliances, and would divert them from their former single expedient of reducing wages, or cutting piece-work prices.

SHIP LOSSES AND REPLACEMENT.

THE official returns issued on Wednesday, of new merchant ship construction in the United Kingdom and in allied and neutral countries, reveals unsatisfactory progress. The output in the United Kingdom during April was only 111,533 tons, which is 50,000 tons less than in March, although better than in February or January. It is considerably less than the average output in the last quarter of last year, the monthly average for these three months having been nearly 140,000 tons. These facts, considered in the light of all that was done in the late summer and early autumn to speed up production, and the promises made that the standard ships could be built in eight months by a great number of firms, proves without doubt that the best is not being got from our shipbuilding resources, from the standpoint of material and *personnel*. This situation cannot be brought too forcibly to the attention of all responsible for merchant shipbuilding, and no doubt Lord Pirrie will take such action as may be required in order to ensure that degree of acceleration the possibility of which is so obvious.

Fig. 1. LOSSES BY ENEMY ACTION AND MARINE RISKS, ALSO SHIPBUILDING OUTPUT OF THE UNITED KINGDOM

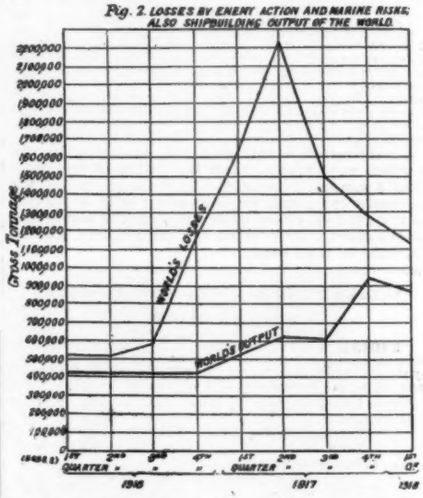


The production of allied and neutral countries is rather more satisfactory. The output for the first quarter of this year is now officially given as 544,327 gross tons, while the average per quarter in 1917 was about 443,600 tons. Both in 1917 and 1916 there was considerable development in shipbuilding in those countries. In 1913 the gross tonnage of vessels built in allied and neutral countries was 873,000 tons, whereas in 1916 it was 1,146,448 tons, and in 1917, 1,774,312 tons. While the figure for 1913 is gross register tonnage those for the later years are, for the United States and some other countries, deadweight capacity, which is much greater than the register measurement. If the rate of output in the first quarter of this year is maintained throughout the twelve months the total should be considerably over the 2,000,000 tons. There is every prospect of this figure being greatly exceeded by allied and neutral countries, because the yards in the United States of America are only now beginning to influence, to any great extent, the replacement of tonnage lost. The output of the past quarter for the allied and neutral countries, shows an increase of nearly 25 per cent. upon the average quarterly output in 1917, while in the case of the United Kingdom the increase is at the rate of only about 10 per cent. It is true that a much larger proportion of the shipbuilding resources in this country are being utilised for the construction of fighting ships and for the vessels operating under the direct control of the Admiralty. In this country, too, a fair proportion of the shipbuilding plant is required for the repair of ships disabled by submarine and other attack, and the official statement is made that since January the increase in the merchant ships which have been repaired and returned to service is equal to 40 per cent. Even so, it is a matter for regret that the increase on the United Kingdom output of last year has not been much more equal to that for the allied and neutral countries.

In order to show vividly how the replacement of tonnage compares with the losses due to the war, we give, first, a diagram showing the United Kingdom merchant tonnage lost through enemy action and marine risks for the past two years, and the tonnage completed during the same period in the United Kingdom. It will be seen that the losses due to submarines continue steadily to decrease, but the check in the increase in tonnage completed is most marked. In other words, the rate of diminution in tonnage lost, as compared with three months ago, corresponds exactly almost to the rate of diminution in output. Thus the lines of tonnage lost and tonnage completed move downward almost in parallel for the past three months, whereas they ought to have been converging lines; if the advance in the last quarter of last year had been continued we should have reached the most desirable stage of output equalling losses. In the first quarter of this year the British losses were 687,576 tons and the replacements only 320,280 tons. This is unsatisfactory, and the fact must be brought home to all concerned in the building of ships.

The second diagram shows corresponding curves for the world's merchant tonnage losses through enemy action and marine risk, and the world's output. Here the results correspond with those for the United Kingdom. The decrease in losses have a parallel in the decrease of tonnage completed.

Fig. 2. LOSSES BY ENEMY ACTION AND MARINE RISKS; ALSO SHIPBUILDING OUTPUT OF THE WORLD.



In other words, the world's total losses between January and March totalled 1,123,510 tons, while in the same period the tonnage completed was 864,607 tons. This, too, notwithstanding that the new tonnage given for some countries is the deadweight carrying capacity and not the gross registered tonnage, which is considerably less than the carrying capacity. There is hope, however, that the situation is gradually improving, and we trust that when the next monthly return of shipbuilding is issued the figures will be much more favourable.

THE CO-ORDINATION OF SCIENTIFIC PUBLICATION.

THE traditional philosopher of ages gone by had a comparatively leisurely time. He pursued his studies in his own quarters, narrow or spacious, little disturbed by what happened outside, without having to bother about meetings or current literature, and provided he did not pretend to be wiser than the authorities, both ecclesiastical and temporal—for which purpose he cultivated an obscure mode of expression—he might finish one or more books in peace in the course of his lifetime. Many of those books were lost to posterity. There remain enough to remind us on many occasions that there is little new under the sun. At present hundreds of learned bodies scattered all over the world are devoted to the advancement of knowledge, and their very multiplicity almost frustrates the endeavours of the investigator, who wishes to acquaint himself with the literature on his subject. Co-ordination of scientific publication aims at assisting the investigator in this arduous task. There are, as Sir Robert Hadfield pointed out in his

recent presidential address to the Society of British Gas Industries, 519 scientific and learned societies in England, and 601 in the United Kingdom; the ist may not exhaust the numbers of all the bodies, field clubs, &c., which publish proceedings at regular or irregular intervals. When the Royal Society took up the indexing of scientific papers that had appeared since 1884, they found more than 1,400 serials of various descriptions and importance in the scientific libraries of London, in more or less incomplete files. The consultation of the Royal Society catalogues and of other indexes requires in itself a study which many original workers do not care to face. What is to be done? The present condition of things obviously suggests that there are too many societies and that too many papers are published. But would the reduction in numbers afford a cure or even mitigate the evil? It is very doubtful. A paper, say, on a new alloy, will interest the metallurgist, engineer, chemist, physicist, even the medical man, from different points of view, and in addition to the few who wish to study the paper *in extenso*, there will be many who expect the editors of their own particular journals to extract for them what concerns them. And how is the reduction to be carried out? So-called co-ordination would really turn into subordination, and there will be few ready to subordinate. Even if we disregard legitimate financial considerations, the problem is as difficult in its many aspects, as it is important.

That much, as well as a very general earnest desire to do something, resulted clearly from the general discussion on "The Co-ordination of Scientific Publication" which the Faraday Society held last Tuesday. It was an informal meeting, mainly of presidents and representatives of scientific and technical societies and editors of influential journals. The discussion was opened by Sir Robert Hadfield, Bart., F.R.S., President of the Faraday Society, who, speaking as a member of the Conjoint Board of Scientific Societies, gave an able and suggestive summary of the problems at issue. Much valuable work of scientific and technical bodies, he pointed out, was lost or impaired in utility for want of organisation and collaboration among the societies concerned. There was far too much overlapping, and work had to be done over again. In his own line of work even he found matters of interest discussed in institutions which had nothing to do with metallurgy. A federation might be brought about without formation of a new society; papers, especially those concerning more than one society, might be handed over by a central body of scientific societies to the leading institute as the one best fitted to deal with it, while each society preserved its own individuality.

In Germany six prominent associations of technical experts had, Sir Robert stated, in 1916, combined under one federation of Engineers, Architects, Iron and Steel Makers, Chemists, Electrotechnicians and Shipbuilders, in order better to face the grave tasks that would arise owing to the war and in the transition from war to peace. The number of associations which had joined this federation or union had since risen to eleven. In Austria the Government, local authorities and manufacturers of high-class steel for girders had associated. In America Mr. Carnegie had presented the Engineering Societies with a spacious and beautiful building, nearly 300 ft. in height. That building, as Professor A. Sauveur had recently written to Sir Robert, made for closer intercourse between the members of the various societies, facilitated the holding of meetings, brought the valuable libraries of the societies under one roof, had rendered possible the erection of a building of greater dignity than the individual societies could have constructed, and led to a considerable decrease of expense. Sir Robert had himself repeatedly been informed in reply to questions that one secretary had talked the matter in question over with his confrères in their rooms before answering. That meant a saving in correspondence, telegraphing and time. Finally, Sir Robert suggested that representatives of the Empire should be appointed on the Councils of such bodies as the Iron and Steel Institute. At present there was a want of touch between the different outlying portions of the Empire.

Like Sir Robert, the various speakers had to refer to various sides of a complex problem, and to avoid the baneful overlapping, one of the great difficulties under discussion, we will group our remarks more as to subjects than as to speakers, though we risk that the individual rights of each speaker may not appear to be fully respected. Dr. A. Schuster, Secretary of the Royal Society, also a member of the Conjoint Board, remarked that the more one thought about the subject, the more one became impressed with its extreme importance and the extreme difficulty of doing anything. He would distinguish two things: the reading and discussion of the papers, and their publication. He would not encourage the springing up of new societies. There was no society in existence, *e.g.*, for geophysics and terrestrial magnetism, but a Committee of the British Association had taken the matter up, discussions were being arranged for in conjunction with the Royal Astronomical Society, and the organisation of the British Association might be helpful in other ways as well. Advance notices of papers to be read, with synopsis of contents, were already customary; but those announcements might better be made through a special journal. In this respect the Society of Chemical Industry (represented at the meeting by Dr. C. A. Keane) stands perhaps foremost at present; they publish notices of meetings several weeks in advance, and have (since the enlargement of their journal with the beginning of the new year) also devoted much more space to early abstracts of the proceedings of the many cognate societies. An excellent proposal was made by Mr. F. S. Spiers, Secretary of the Faraday Society. It was that the secretaries of societies of allied interests should exchange views with one another before deciding upon the calendar for each year, as to subjects to be brought up; that would, or should, avoid much overlapping, and make the discussions more valuable. Mr. Spiers had originally also, as Sir Robert Hadfield had stated, been in favour of the Central Bureau for allocating papers submitted to the most suitable society or for arranging joint meetings. Last Tuesday Mr. Spiers said that that suggestion went too far perhaps; he had also pleaded for a geographical co-ordinaton of papers, keeping the chief papers in London, and sending those of specialised interest to local centres. Professor R. A. Gregory, whose written contributions to the discussion seemed very much to the point, thought that to mention that Central Bureau plan was almost sufficient to condemn it, and most other speakers agreed that the suggestion would not find favour. Mr. Michael Longridge (President of the Institution of Mechanical Engineers) remarked that members would always prefer to read their papers before their own societies; there were, moreover, prizes offered. Mr. C. H. Wordingham (President of the Institution of Electrical Engineers) pointed out that the arrangement would not advance the interest of the specialised societies and would lower the quality of the papers; and Mr. W. R. Cooper said he would be sorry to disregard the importance of individuality.

As regards publication, Dr. Schuster further pointed out that the proceedings of most societies were all different in style and size. The Royal Society had once agreed with the Royal Astronomical Society as to the style of publication, but that arrangement had not been adhered to afterwards unfortunately. If all the publications of proceedings were of the same style—they are in the case of the main engineering societies and the Institute of Metals, as Mr. G. Shaw Scott mentioned—papers could better be kept and filed together in the same cover, and separate reprints would be cheaper to all concerned than republication of the same papers by different bodies. That latter point was generally conceded. The various joint discussions of the Faraday Society, Mr. Spiers mentioned, were available in reprints, together with full discussions, and the arrangement was not unprofitable to the Society. There is, of course, another side to the question. If reprints be rendered too easily accessible, one of the inducements for joining a society will fall; that was pointed out by Mr. J. G. Pearce and others. The suggestion of pooling the libraries of cognate societies called forth more diverse opinions. Mr. Edgar Worthington remarked that card-indexing and cataloguing and finding one's way about could be managed in a library like that of the Mechanical Engineers, but it might become beyond the power of one man if all the libraries of the scientific societies were to be united, and then Manchester and Birmingham, &c., would want their libraries as well as London; several libraries could always keep in touch with one another by telephone. Mr. L. Pendred said he considered the difficulties of the common library, and especially of the classification, enormous; all card indices became too complicated in the long run. Mr. Longridge thought that a College of Librarians was more important than the one common library; he would appoint a number of well-educated, well-paid young men, to keep track of researches carried on, so as to be able to give an inquirer the necessary information concerning matters and books to be consulted. The suggested college of librarians found favour with others present. We are a little doubtful, and would, in any case, prefer older men of some experience to younger men for this work.

The advantages of a united engineering societies' building were acknowledged. Mr. L. Mond (Treasurer of the Faraday Society) reminded the meeting that the New York building, the home of engineering societies, had had a predecessor in the very house in which the meeting was being held—Burlington House; it accommodated quite a number of scientific societies, but was no longer sufficient for the purpose. Mr. Mond considered that a centre of science was needed. Mr. Thomas Wright, who recommended the Dewey decimal system of indexing in use in New York, doubted whether the Institution of Civil Engineers, which had put up two new buildings within recent years, would welcome the idea of a new central building.

Between the bare index and the work itself stands the abstract. In the last decades abstracting has made great strides with the result that there is overlapping of the abstracts as well as of the original communication, again for the same reason, that the interests of different classes of readers have to be studied. In this country, Science Abstracts, the Athenæum, the abstract columns of the great engineering institutions, of the Chemical Society and of the Society of Chemical Industry and of some journals deserve credit for the great help they afford to the student. The two last-mentioned societies have recently agreed—the matter is not quite settled, however—not to encroach any longer upon one another's domains, and to discriminate, in their respective abstract columns, between pure and applied chemistry. Something similar, it was mentioned during the discussion, might be done in other branches. The difficulty comes in here, as in other fields, with science from the borderlands, generally the most fascinating of all sciences. Physical chemistry seems to comprise all theoretical chemistry, electrochemistry has much in common with either parent science, and technical chemistry, though not hailing from the borderland, is as much the science of the engineer as of the chemist. But science, after all, is one; the value of a great research lies in its bearing upon all branches of science, and the scientist has to consult "Science Abstracts" or some similar publication in addition to the abstracts of his own branch.

The question of societies and branches received due consideration. The Institution of Electrical Engineers and the Society of Chemical Industries have done a great deal for the interests of their members in the provinces; the Faraday Society also has its affiliated branches. Those branches might form local associations of their own; provincial members, Mr. Longridge remarked, had just cause to complain that their membership of the big London institutions did not offer them many advantages. That brings us back to the question of the justification of new societies. Mr. Cooper stated that he used to think: the fewer societies, the better; but he had changed his opinion. The Faraday Society—founded in 1903—could never have done its great work, if it had been or become a section of the Institution of Electrical Engineers, or had amalgamated with the Physical or the Chemical Society, as had been suggested in the

early years. The Faraday Society has certainly justified its existence, and its remarkable success should silence those who feel inclined to put a veto on the foundation of new societies. But nobody thinks of an absolute veto, and a general tendency to check the birth of new societies, and not less of new journals, will probably do more good than harm. Councils might, however, discourage hasty publication of unfinished researches and thus save much paper and time. Our age is too much in a hurry, we said last week in an article on "Scientific Unrest." Scientific co-ordination might do something towards improving the quality of some publications, in the form of papers and of books as well.

Many other suggestions offered might be mentioned. Some of those made by Mr. Y. G. Pearce in a contribution, that had its good points, will hardly meet with full approval. He would admit all the members of all the prominent technical societies to all the meetings of these societies, and offer them their proceedings at a nominal charge; he advocated the systematic preparation of text books for students by experts under the guidance of the Department of Scientific and Industrial Research; he would develop schools of library science for the training of indexing experts, and would weld all the indexing agencies into one. Mr. P. Peakman and Miss Margaret Benson, M.Sc., of the British Westinghouse Company, Manchester, proposed weekly publication of research, done both in the universities and in the works. We do not wish to press financial considerations and personal interests at this stage; they will duly be urged in proper time. But even the most reasonable financial caution would oppose some of these proposals. We further feel that the spirit of centralisation which seemed to inspire almost all the speakers at the meeting will have toned down somewhat by the time the general suggestions have been examined in detail. The popular tendency, we fancy, is not for centralisation. The necessity for organisation and co-operation is more and more universally recognised. Hand in hand with it go, however, an antipathy to State interference and external regulation, and a revival of the old confidence in individual independence and strength.

NOTES.

RIVETING.

A riveting squad at the works of Messrs. Fraser and Fraser, Limited, Bromley-by-Bow, have performed what we believe to be a record test, not only from the point of view of the number of rivets closed by one gang in a day of 9 hours, but which is more remarkable that all the rivets were "knocked down" by one riveter. The firm are making a number of special oblong tanks with rounded ends for the Food Ministry; they are constructed of $\frac{1}{4}$-in. plate with angle steels of $\frac{1}{4}$ in. thickness round the top and $\frac{3}{8}$ in. thickness round the bottom; the work to be carried out consisted of the riveting of these angles to the top and bottom of the tank and the vertical joint of the tank. The rivets were $\frac{1}{2}$ in. diameter by $1\frac{1}{4}$ in. long, with snap heads; the head formed on the inside of the tank was of the tank flat type. The squad who set themselves the task, consisted of the riveter, who used an Ingersoll "Little David" pneumatic riveting tool (weight $28\frac{1}{2}$ lb.), the plater who removed the tacking bolts and faired the holes, &c., and two holders-up, besides four lads who looked after the two rivet forges and heated and carried the rivets. The work started at 6.30 a.m. on the morning of May 7, and continued until 5 p.m., with half-hour break at 8.30 a.m. for breakfast and one hour break at 1 p.m. for dinner. The total number of hot rivets closed by the one riveter was stated to be 4,276 during the 9 hours, which is at the rate of 7·9 rivets per minute or, say, one rivet every 7·6 seconds; this is a heavy day's work for one man, although he was throughout ably assisted by his mates in the squad; it is understood that all the men are members of the Boilermakers' and Steel Shipbuilders' Society. We were informed that the task was undertaken to demonstrate that the riveters of this country were quite capable of performing work equal to that in the United States of America, when 2,720 rivets were closed in a day of 9 hours by an American squad of riveters; this is equivalent to 5 rivets per minute or 1 rivet in 12 seconds.

CHAIN FENDERS AT PANAMA.

One of the points that had to be considered in deciding whether to adopt a locked or sea-level canal at Panama was the danger of lock gates being carried away by a vessel getting accidentally out of control. To guard against this contingency it was decided to use electric locomotives for handling all ships through the locks. These locomotives run on rack railways laid alongside the lock wall, and the system has proved very satisfactory in working, the vessels being kept well centred in the lock chambers. Duplicate gates were also used in certain positions, together with guard gates at both ends of each lock flight, whilst emergency dams of the drawbridge type are also provided at the upper end of each lock, by which the flow of water can be controlled in case of serious injury to the gates. To protect the gates from destruction by the impact of a ship in passage chain fenders were fitted. These were described and illustrated in our issue of July 31, 1914, where also particulars were given of certain tests made to establish the efficacy of the design. The novel feature in the design is the use of hydraulic power for manipulating the chain and of hydraulic resistances for absorbing the kinetic energy of a colliding vessel. The valves controlling the chain gear are interlocked in such a way that the chain cannot be lowered into the clear position unless the gates are fully open. The tests of the hydraulic gear which were described in our previous article have since been supplemented by tests made by causing large ships to collide with the chain. These tests are described in a paper presented to the Canadian Society of Civil Engineers by Mr. Henry Goldmark, the designer of the gear. The tests were made at the Gatun lock in 1915. Two ships were used in the tests, the Alliança, of 4,221 tons displacement, and the Cristobal, with a displacement of 18,000 tons. The first series of tests were made with the smaller vessel moving at speeds of 1·23 miles to 3·38 miles per hour, 12 runs being made in all, whilst 10 runs were made with the Cristobal, the highest speed attained in her case being 2·45 miles per hour. In all tests the vessel was stopped before the chain had paid fully out. No injury was done to the vessels and the chain was only slightly marred. In the case of the Cristobal the vessel was brought to a stop within from 51·5 ft. to 62·0 ft., the latter being the deflection of the chain when the speed was 2·45 miles per hour. This vessel was about 500 ft. long by 58 ft. wide, and the energy absorbed in bringing her to rest was some 4,000 ft.-tons to 5,000 ft.-tons.

THE LOCHABER POWER SCHEME.

Those who see in the full development of our national resources the sole prospect of liquidating our enormous war debt without great distress to the community will be shocked at the rejection last week by the Peers of the plans of the British Aluminium Company for the further utilisation of water power in Scotland. Some of the speakers seemed to accept the view that any individual who founds or establishes a new and profitable industry becomes *ipso facto* an "exploiter" of labour and a public enemy. Lord Balfour, for example, who moved the rejection of the Bill, urged that work of this kind should not be undertaken by a commercial company for private profit. The almost inevitable result will be a great delay in developing the water power available at Lochaber, and the national wealth will be diminished by the loss during this period of many tens of thousands of horse-power. There will also be a direct loss to the locality, for the British Aluminium Company had agreed to pay the Board of Trade a royalty for the water rights. This money, amounting probably to £6,000 a year, the Board would have handed to the Local Authorities, who, in addition, would have levied rates on all the works, the value of which would have been at least a million sterling. The work, if finally carried out by the community, will certainly cost more to effect, in view of the admitted inefficiency of our Government departments. The capitalist, of course, will not suffer, since in such case the money will be raised by loan. His dividends will be secure, whilst all the risk of failure will fall on the community. Of course, it will be maintained that large profits will be reaped which would otherwise go into private pockets. Publicly operated services have, however, the knack of seldom making large profits unless protected by law against legitimate competition. Little initiative or capacity is then required, but even so, the promised profits do not always materialise. It may be observed, by way of illustration, that by allowing Mr. Carnegie a free hand, America developed her steel resources much more rapidly and certainly at a less cost to the community than had the attempt been made to develop them on national lines. An administrator of Carnegie's exceptional capacity cannot work well in harness. A man will take risks when he is responsible solely to himself, which he would fear to do had he to account for his every action to a committee. Steel has made modern America. Without the rapid development of the industry there the railways could have been neither built nor equipped, and the whole standard of living of the community would have been materially lower than it is to-day. Even had the free scope given to Carnegie done no more than advance matters by a score of years, as compared with a development on national lines, the gain would be cheap at a price much higher than has actually been paid for the service. In the present crisis American steel has indeed gone far to save civilisation. Considerations of this kind ought not to be ignored in discussing industrial developments of the future. Co-operative societies have been manufacturing on a large scale for many years. So far as we know there is not a single instance in which they have made any important improvement in industrial methods or been responsible for the introduction of any really valuable novelty. As Emerson pointed out years ago, fertile ideas always originate with an individual and never with a community, and it is equally true that a really novel idea prospers only if it has the benefit of individual care during its early stages. If left to alien hands it commonly perishes, and has to be reborn in the mind of some more faithful or able parent.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN ordinary general meeting of the above Institution—the last of the session—was held on Friday last, the 3rd inst., at the Institution of Civil Engineers, Great George-street, Westminster, the president, Mr. Michael Longridge, occupying the chair.

The formal business of the meeting was first transacted, and the announcement made that the ballot list showed 86 candidates to have been elected to the several classes of membership, while several transferences had been made from the class of associate member to that of full member.

EMPLOYMENT OF WOMEN IN MUNITION FACTORIES.

The president directed attention to the fact that a paper entitled "The Efficient Utilisation of Labour in Engineering Factories," would that evening be read by the author, Mr. Ben. H. Morgan, and would be discussed in conjunction with the paper on "The Employment of Women in Munition Factories," read at the previous meeting by Miss O. E. Monkhouse, the author, and partly discussed.

Sir Herbert Austin opened the discussion. He heartily agreed with the remarks of both authors in regard to the employment of women, having had experience in the case of 6,000 women workers and 14,000 men. Some of these women had been engaged on shell work; others on the finest operations connected with grinding and machine work previously considered to be entirely a man's job. Holding the views he did, it was difficult to criticise the papers. The paper by Miss Monkhouse did not admit of much criticism, its facts being quite definite and the opinions expressed being in agreement with his own. He believed that many employers had been blamed for slackness because their real reasons for not employing women were

not apparent. He would mention one or two other reasons than the fear that women would be unable to do the work assigned to them. He was confident that many employers supposed that if they went to the expense and trouble of installing women their procedure would not be followed by other manufacturers, or the latter would not be compelled by the Ministry to put in the same proportion. Looking to the difficulties attending the employment of unskilled labour and the changes in the works and fittings involved, the inequalities in the application of dilution rendered some manufacturers disinclined to follow the wishes of the Ministry in respect to introducing dilution from time to time. He had noted that, in his immediate neighbourhood, there were certain factories in which there was no dilution, due in part to the fact that they were carrying out Admiralty contracts, in which they had preference. On the other hand, firms who were executing munition Ministry contracts had not the same protection. Moreover, the Ministry was made up of quite a large number of departments, and it was not the dilution officers who attached blame to firms for not turning the work out quickly and properly and making a good job of it, but the other departments, who had no sympathy whatever with dilution. A year or two's experience of the difficulties just referred to rendered manufacturers less ready to meet the requests of the dilution officers so freely as before. Personally, he had reached the point when he disliked seeing the dilution officer. To two such officers, who had been in his factory nearly a week, he had had to explain that he could really give no further assistance; he believed that there were several other firms in the country similarly placed; they had done their fair share, and, as Mr. Morgan had pointed out in his paper, it should be made compulsory for others to do theirs. In such cases, Sir Herbert considered that the ability of women to do the work of men would not be discussed; it was generally admitted.

A point, not touched upon by either of the authors, was the fear entertained by several firms whether women would be available after the war, and whether the time occupied in teaching women and making provision for them in the shops would be worth the expense and trouble. Before the war he had set his face against having any women in the factory; he had not thought it necessary, and, now, he was looking forward to the employment of men in the factory and the disuse of women. This was not because they had not done their fair share; they had done more. When the war was over, and the work of skilled and unskilled labour was summed up, women's work would stand in front of unskilled labour. He did not approve of employment of women on men's work. It was a man's duty to do the hard work of an engineering shop, while for women there was other work, better suited to them. The advocates of women labour seemed possessed with a fear as to whether facilities would be given to women to work, but the speaker was most concerned with the question of whether the women themselves would be willing to work; they might be tempted to carry their energies into other spheres and would discontinue the work they had been doing so well in the engineering factories. The speaker doubted if Mr. Morgan was acquainted with all the difficulties with which manufacturers had to contend, and whether, perhaps, he had considered, on the question of efficiency and allowance for output, the changes in design that had to be made, particularly in the case of aeroplanes and aeroplane engine contracts. He would be interested to know what Mr. Morgan had to say as to figures for output per man-hour. Frankly, he could not see, having regard to aeroplane work and the difficulties incidental to change of design, how such a figure could be laid down.

Sir Guilford Molesworth, who spoke next, commented on the practical sound sense and logicality of Miss Monkhouse's paper. Women had proved their ability to perform efficiently the work usually regarded as exclusively within the domain of men. Women's work would not end after the war; if not employed on munitions, he was confident that they would be engaged on the urgent work required to recover lost industries and repair the wastage of the war. He was anxious, however, that they should not fall into the pitfalls of trade unionism. At the outbreak of the war, the speaker had offered voluntary service to Messrs. Vickers at Crayford; this had been accepted, and he had worked there for nearly five months. Observation showed him that the output of munitions was wantonly restricted. In a letter to the Minister of Munitions he had alluded to this slackness, and urged that the substitution of women for men would, without enlarging the number of workers, greatly increase output. Further, that for certain classes of work the shops should be organised for the employment of women, who should be protected from intimidation. Official tables, published in December last showed the results of substituting women's work for skilled labour in producing the 9.2 shell in a national workshop. In connection with these it was stated that "whereas the complete boring of the shell required 3.16 hours when done by skilled men it was accomplished in 3.3 hours by women after only one week's practice, and within two or three months the women had reduced the time to 1.25 hours, thus increasing the output to 2½ times the previous figure.

Miss Anderson remarked that she approached the subject of the papers from the end opposite to that of Mr. Morgan, who was mainly interested in placing Government contracts where the conditions, as regarded material and labour, were likely to prove most successful. The speaker, however, was more concerned with the safeguarding of the life and health and the limbs of the workers. Enlarging the comparison, she was less interested in quality and quantity of labour than in the quality of the life of labour; with rational organisation the two aims might advantageously meet, and were, she considered, interdependent. She was better acquainted with the employment of women in non-munition industries than in those of engineering, and in the former case the Home Office and Board of Trade publications indicated how great the development had been. There was not the same specialised training, and it was not yet known what could be done in the various directions taken by women labour. She was of opinion that the fullest application should be made of the particular gifts of women workers where such gifts could most aid industry. She agreed with Sir Herbert Austin that women should not be too largely employed to do the special work of men—the heavy labour peculiarly suited to the latter.

Mr. C. Faraday Proctor, the next speaker, had had some six or seven years experience of the employment of women. In 1881 he had gone to France to start the manufacture of incandescent electric lamps. The work being delicate, he employed girls, and returned to England to teach women processes developed in France. Later he established big works in France, again employing women. In glass blowing, the German men, who monopolised the work, refused to allow more boys to be taught, and as men were unobtainable, his only expedient was to employ women. The latter soon did as well as the men, and turned out greater quantities; they put their energies into the work and made no attempt to restrict output. In another branch of work—the clerical—he had found women very neat and deft. The speaker had always urged that women could do the work of men, almost in everything. He regarded better education as essential to women, particularly in the direction of mutual understanding as between women and men. In France and Germany women were better educated, and took a good interest in their work We, in Great Britain, were not any longer masters in engineering; other nations were catching us up. It was necessary to improve our status, and he regarded the utilisation of women in works as one means of so doing. Women, he considered were more suitable than men for small accurate repetition work, and he attributed this to the fact that a woman's mind was not wholly given to the work she was doing; she was probably thinking of other things. He had frequently been asked why women were not paid at the same rate as men, and he found the reason in the fact that between the ages of 20 and 30 she was a "doubtful" employee; she might at any moment marry, and her training be wasted. On the point of the accuracy of women's work, he need only refer again to the electric lamp, with its filament, $\frac{1}{1000}$ in. in diameter, or less, produced from the hardest of wires almost entirely by female labour.

Mr. John Abbott was in entire agreement with the authors. Speaking from twelve years' experience of female labour, he did not concur with the remark made at the previous meeting—that women were less conscientious workers than men. He had found the reverse to be the case, but that might be attributed to the circumstance that in the factory he had been connected with the females were better looked after than the men. There were welfare supervisors, whose duty was to make suggestions for the betterment of conditions for the women, whereas boys would often get nothing of that kind. He regarded female supervisors as essential. Where a man would be at a disadvantage in dealing with women, one of their own sex would not. Beyond that, however, he felt that where women were employed there should be a really reliable welfare worker, who, although somewhat of a thorn in the side of a works manager, nevertheless kept matters straight, and enabled the manager to concentrate his attention upon the things that mattered, relieving him of details. Looking to the responsible character of their position, the Government should do—and were doing—much to educate welfare workers, who needed to be carefully chosen and to have the full confidence of the employer and the employees, if failure were not to result. So long as health was legally protected, he felt that the employment of women was not only for the period of the war. In fair competition women would retain their jobs, but if trouble were to be avoided the rate of pay should be the same as for men, the product being equally satisfactory.

Major F. Heckstall Smith spoke next. He expressed the opinion that the early stages of dilution could be reached on the designer's table, a point much overlooked. It would have done good had the Ministry of Munitions some time ago brought that point out, but it was not now too late. Referring to Sir Herbert Austin's remarks, the speaker had, before the war, employed women on aeroplane building, and he hoped so to employ them after the war. While at the moment the employment of women was a matter of absolute necessity, after the war consideration should be given to the fact that the prosperity of any country was largely dependent on family welfare, i.e., better education, health and housing of the workers. This, in turn, was dependent on the amount of money a family could earn, which, again, was contingent on the maximum number in a family obtaining employment. In his own experience, in a somewhat remote place, it was found difficult to secure the large number of mechanics needed. Housing was expensive, and it became indispensable to employ women—before the war—in order that the people might earn enough to live upon. This state of things he regarded as a reason for giving serious consideration, after the war, to the subject of the employment of women from the national welfare standpoint. Sir Herbert Austin here observed that he had confined his remarks to employment of women in engineering and not in other factories.

Mr. William Reavell alluded to Mr. Morgan's remark to the effect that women had excelled more in machining than in fitting work. He would ask what the author meant by "fitting" work, whether the fitting of parts which would go together without requiring the use of a file or reamer—such as fuse fitting, or skilled fitting, where, on the work coming from the tool, a fine file or scraper was applied before fitting together? His experience showed that in fuse fitting, as distinguished from skilled fitting, women's work was quicker and much superior to men's, due to deftness of touch and neatness of fingers. This was especially the case in piece or bonus work. After three years' employment of women the speaker had put them on capstan lathes and milling machines, where the work could be set up for them from the tool-room, and was largely repetitionary, and their assiduity and disregard of the maximum output question led to excellent

results. On more difficult work, such as fitting the parts of complicated machine castings, his experience of women had been less satisfactory. The skilled fitter could not be replaced even by the best selected girls; nor were the latter so interested in fitting work as in machine work, provided, of course, the machine was arranged for woman's work. With capstan lathes, for example, it had been necessary to lengthen the handles of the star wheels, and to introduce small changes and modifications, among others, stools for the women to stand upon. Regard must be had to stature, and the principles of motion study should be applied. He would mention, by way of illustration, that certain work executed, before the war, at a certain rate and an accelerated rate since the war began, did not reach the expected output. A quantity of this work was turned over to the women, with the result that the output of the best man on the capstan lathes in their main shop was exceeded by the women after a week's work. The women seemed willing to go "all out," an object-lesson for the men, and one for the learning of which employers would gladly pay more money.

Mr. E. R. Dolby remarked, in connection with Mr. Reavell's observations, that the term "assembling" was already suitably employed to connote the putting together of any given object where further adjustment by removal of metal was not required, and the term "fitting" might properly be applied to the operation of adjusting by further removal of metal before putting the parts together.

Miss O. E. Monkhouse replied to the discussion so far as it concerned her own paper. She observed that she was fortunate in having little opposition to meet, and therefore needed little courage to speak. Several speakers had definitely stated, or else strongly implied, that women could never be "engineers" proper. She held no brief for women as engineers, but some speakers had attempted to prove that women could not be engineers, while their remarks went to show that there was nothing to prevent a woman being an engineer, provided she had not the usual domestic claims upon her time. Mr. Wicksteed had asserted that women could not be engineers, but had stated that his women workers had improved in health and strength since they had been with him; that as they became better disciplined and more experienced their work improved; and that things were now going on as nicely in his factory as formerly they went wrong. Those remarks all testified to the mental and physical fitness and to the commercial value of the woman worker. He had further observed that in his factory scrap had been reduced to 1 per cent. Against the employment of women no one had anything to urge but their domestic claims. This, Mr. Wicksteed stated, made them bad time-keepers, and prevented them from carrying out the full engineering course expected from a boy. Thus, instead of proving that women could not be engineers, Mr. Wicksteed had merely brought out what was common knowledge—namely, that, whatever the line taken, a woman had to feed, clothe and nurse her men folk and children. This was a disability, since a woman could not lead the life of a man and woman combined; but it in no sense proved the mental unsuitability of women to be engineers. Another point brought out was that men should have the same care for their welfare as women. Women, however, were not opposed to that; they would indeed, encourage the idea. Men should be well fed and given opportunities to leave the works clean and self-respecting. She would ask anyone interested to visit some of the dock canteens, where the labour was rough and the conditions shocking. There were admirable organisations run by the Y.M.C.A., under the able presidency of Lady Asquith, which supplied the dock workers with hot meals at a moderate cost—breakfast, lunch and tea at places within a reasonable distance from their work. The men took striking advantage of these organisations for their welfare. The numbers increased day by day, and the canteens had become self-supporting. Several speakers had referred to education, and there was no doubt a need for this. Often the reason why women were not a success was because men had not thought it desirable to explain to them the technicalities of the work, believing that women would not understand. She was aware of a forge in which women had been very unsuccessful in regard to output and consumption of tools. On the matter being explained to them, together with the small technicalities essential to improvement, the tool consumption of the women had improved by 73 per cent. In conclusion Miss Monkhouse desired to acknowledge the compliment paid to her sex in the invitation made to her to read a paper before so important an institution. She sincerely hoped that employers and trade unions would see that women were retained in those occupations for which they were particularly fitted, and that greater encouragement would be given to them to take up skilled work. It should be seen to that women did not degenerate industrially; that they did not become laundry slaves and sweated tailoresses, employed largely by undesirable aliens. By "encouragement" she meant that women should be given a definite place in the industrial system, be recognised by the unions, and be provided with educational facilities in technical schools and universities, such as would fit them to rise to the higher places in engineering, chemical, and allied industries.

Mr. B. H. Morgan regretted that the constructive feature of his paper had not been dealt with in the discussion in greater detail, as he would much have liked to have had the views of men of affairs on the question of setting up standards in order to bring about some equality in the labour conditions of the country. He would first refer to certain interesting points raised by Sir Herbert Austin, among them whether it paid to train women, in view of the limitations that might arise in their use after the war. The speaker considered that, in approaching dilution, the question must be regarded as purely a war measure; its economic side should not be emphasised. He regretted as sad the experience of Sir Guilford Molesworth in relation to trade unionists at Crayford. Speaking generally, the Ministry of Munitions had received the loyal support of trade unionists in bringihg about the wide employment of women in this country. Whatever the co-operation of employers or the action of the Ministry, the employment of nearly a million women could not have been effected without the most strenuous and yeoman service on the part of trade unionists, who had actually themselves trained these workers in the factories. There were local obstructionists, but the great body of men were sound in supporting any measure to win the war. Miss Anderson was probably the greatest authority on women's work, and in relation to her remarks on the subject of health, he regarded it as a truism—though not realised—to state that efficiency of production would always coincide with the greatest consideration of the health and welfare of workers. He believed Mr. Reavell to have in mind assembling with a certain amount of fitting. What the speaker had referred to in his paper was bench fitting, such as shaping of parts with the file—small arms and machine gun parts involving a great deal of file work.

The President then announced that the two papers just discussed would be read, and further discussed, at the Medical Lecture Theatre, Birmingham, on Thursday evening, May 9, and at the Engineers' Club, Manchester, on Friday, May 10. He would further ask the meeting to pass a vote of thanks to the Institution of Civil Engineers for lending their room. The next meeting would not take place until October, by which time he trusted the Institution would be within sight of getting into its own building again.

In concluding the business, Mr. Longridge drew the attention of members to an apparatus he had on view for testing the hardness of steels with Brinell numbers under 600, or lower. The apparatus, named the Boyelle-Morin apparatus for testing hardness of steel, had come to the speaker's notice at the Munitions Inventions Department, where it had been sent as an invention. The Department had requested Mr. Bowen Cooke of the London and North Western Railway Works at Crewe, to try and test the apparatus against the Brinell machine. Mr. Bowen Cooke had done so with steels varying from 0.15 carbon up to 0.64 carbon, that was to say, steels with a tensile strength of 29 tons to about 56 tons. As an average, Mr. Bowen Cooke had found that the difference between the simple apparatus exhibited and the 3,000 kilog. Brinell apparatus was rather more than 2 per cent. In three cases the difference was 7 per cent., while in six cases the difference was under 1 per cent.; the other cases were intermediate.

THE LATE SIR WILLIAM HASWELL STEPHENSON.

FULL of years, and with a remarkable record of useful work, there has passed away, in the person of Sir William Haswell Stephenson, a typical Northumbrian who did much for the development of Newcastle and of the River Tyne. Indeed, it would be difficult to exhaust the list of enterprises, both of a corporate and commercial character, in the advancement of which he assisted. He died at his town residence, Elswick House, Newcastle-on-Tyne, on the 7th inst., aged 82 years.

Born on May 15, 1836, the son of the late Wm. Stephenson, of Throckley, Northumberland, the subject of our memoir was educated successively at Mr. Weeks's School at Ryton, at Brampton, and at Wesley College, Sheffield. At the age of 17 he began his business career with Messrs. Joseph Heald and Co., but later entered upon the management of his father's many undertakings. Perhaps the most important of these, in addition to mining, was the production of fire-clay and similar material for the lining of gas retorts and blast furnaces. The coal field was at Throckley, and it is indicative, not only of one of the strong characteristics of Sir William, but of his fixity of purpose, that the Throckley village never had licensed premises, so that it is probably almost unique as a prohibition community.

Sir William, however, was best known for his public service in Newcastle-on-Tyne, and especially for the improvement of the River Tyne. Indeed, it was during his long *régime* that the building of large ships became possible. He joined the Tyne Improvement Commission in 1878, and from 1900 until his death he was chairman, being elected annually almost as a matter of course. In the City Corporation he took a prominent part from 1869 onwards. In 1875, he had the somewhat unusual distinction conferred upon him of being elected Mayor although he had not served as a sheriff. He was Mayor for four years, and after Newcastle became a Royal Borough he served three times as Lord Mayor. He was a ready speaker, clear and logical, and with a fine grasp of commercial and financial matters, so that he well represented the city on all occasions, while doing useful work in general administration. He erected libraries at Elswick, Heaton and Walker, and, at his own cost, in 1903, he erected in St. Nicholas Square, the bronze statue of Queen Victoria, by Sir Albert Gilbert, R.A. He was a great supporter of the Newcastle Wesleyan Mission, serving for over 45 years as a local preacher. It was fitting that in 1911 he should, therefore, receive the honorary Freedom of the City. He was also a Deputy-Lieut. of the County and an Honorary D.C.L. of Durham University. The honour of knighthood was conferred upon him in 1900. He was chairman of the Newcastle Commercial Exchange, and a great variety of commercial and industrial undertakings, particularly in the North of England.

TRADING WITH THE ENEMY ACT.—The Controller of the Foreign Trade Department has sent us a copy of a new list (No. 53) of additions to the Statutory List of firms of enemy nationality or enemy association with whom persons in the United Kingdom are forbidden to trade. Copies of this list can be obtained at a trifling cost from the Superintendent of Publications, H.M Stationery Office, Imperial House, Kingsway, W.C.

PERSONAL.—The Smith Gas Engineering Company of Lexington, Richmond C., Ohio, has moved into its new factory at Dayton, Ohio, where the main offices of the company will be located. The factory at Lexington will be operated as usual on certain classes of work. All correspondence thereafter should be addressed to Dayton. —Mr. S. W. Clough, of Valley Engine Works, Shipley, Yorkshire, has recently appointed Messrs. C. H. Joyce, Limited, 134, Southwark-street, S.E., as agents for the sale of lathes of his manufacture in the London district.

NEW FERRO-CONCRETE SHIPYARD IN DENMARK.—Under the style of the Codan yard a new concern has been formed in Denmark with offices in Copenhagen and yard at Köge, lower down on the coast, where an area of 40,000 sq. m. has been secured, with facilities for extension. The yard will build both ferro-concrete vessels and wooden vessels; for the former there will be three slips, calculated for building vessels up to 1,000 tons, and for wooden vessels there will also be three slips, with capacities up to 600 tons. Several of the raw materials can be procured in the neighbourhood, and the start seems to take place under favourable circumstances.

INDUSTRIAL NOTES.

In February, 1918, an agreement was concluded between certain employers' and operatives' associations connected with the building trade in Scotland for the adjustment of wages during the war. The agreement provides for the suspension of the previously-existing agreements and practices under which applications for general advances in wages have been dealt with, and for the substitution therefor of a special procedure whereby the Committee on Production may be called upon to consider, at intervals of four months, namely, in February, June and October, what general alteration in wages, if any, is warranted by the abnormal conditions then existing and due to the war. The first hearing under the agreement took place before the committee on April 22, at Glasgow, when an application for an advance of 6*d.* an hour was considered. By their award of April 29 the committee have decided that workmen who, since the outbreak of war, have received general advances amounting to 3½*d.* an hour or upwards but less than 5*d.* an hour shall receive such further increase as shall make the advances up to 5*d.* an hour above pre-war rates. In cases in which the general advances have amounted to less than 3½*d.* an hour, the workmen concerned are to receive a further increase of 1½*d.* an hour. The award took effect as on the first full pay in April, 1918.

The Committee on Production have issued their awards on the claim for an advance of wages to dock labourers so far as regards the ports included in the reference to the committee other than London. The claim was put forward by the National Transport Workers' Federation on a national basis and included a claim for the payment to the men concerned of a bonus equivalent to the bonus of 12½ per cent. granted to munition workers. The award of the committee in settlement of the claim submitted to them is:—Where the war advances already given to the men concerned are 5*d.* per hour, and upwards, there shall be paid such further increase as shall bring the total war advance up to 7*d.* per hour. Where the war advances already given amount to less than 5*d.* per hour there shall be paid a further war advance of 2*d.* per hour. Daily workers and weekly workers shall receive advances proportionate to those granted under this award to men paid at hourly rates. Extra payments, if any, made for overtime or for night work, or for Sunday work, shall continue to be calculated according to the existing practice at each port, but on the basis of the increased hourly or daily rates fixed by this award instead of the existing hourly or daily rates. The advances awarded cover, and are to be deemed to be in full satisfaction of any claims with respect to the bonus of 12½ per cent. The new rates are payable as from the commencement of the day shift on Monday, May 6. The committee have approved proposals of the parties that the committee shall, every four months, after hearing the parties, consider what general alteration in wages, if any, is warranted by the abnormal conditions then existing and due to the war.

The award in the case of London will be issued shortly.

The following are some recent decisions given by the Committee on Production on cases which have been referred to them by the Ministry of Labour, including cases arising out of the Orders under which a bonus to munition workers has been given:—

Wrought Hollow-Ware Trade: Plain time workers are to receive a bonus of 12½ per cent. and piece workers a bonus of 7½ per cent. on earnings from first pay after January 1, 1918. Drug and Fine Chemical Manufacturers: The men concerned, aged 18 and over, who have received war wage advances amounting to 15*s.* and over, are to receive such further increase as shall make their advances up to 20*s.* per week; where the advances amount to less than 15*s.* per week, the men concerned are to receive an increase of 5*s.* per week. Female workers aged 18 and over are to receive an advance of 3*s.* per week, subject to a maximum of 15*s.* per week, over pre-war rates, and youths are to receive an advance of 2*s.* per week. Admiralty Employees: The workpeople concerned (domestic employees and others at naval hospitals and other institutions), with the exception of those in receipt of ration allowances, are to receive an advance of 5*s.* per week, subject to a maximum of 20*s.* per week over pre-war rates from first full pay following March 22, 1918. A claim was also made for a bonus of 12½ per cent. on earnings, but this claim was disallowed.

We read in *The Yorkshire Post* that a powerful combination of British companies in preparation for after-war developments is indicated by the registration as a private limited liability company of the French Iron Ore Company, Limited. The nominal capital of the company is fixed at 17*l.* in 1*l.* shares, and its object is set forth as "to carry on all kinds of exploration business in France and elsewhere, and to prospect, examine and explore mines and ground supposed to contain metals and minerals." The nature of the combination is shown by the list of first directors, who are Mr. M. Mannaberg (representing Appleby Iron Company), Colonel J. R. Wright (Baldwins, Limited), Sir H. Bell, Bart. (Bell Brothers, Limited), Mr. J. Williams (Bolckow, Vaughan and Co., Limited), Mr. B. Talbot (Cargo Fleet Iron Company), Mr. J. B. Allan (David Colville and Sons, Limited), Mr. G. Ainsworth (Consett Iron Company), Lieutenant-Colonel W. D. M. Thomson (Dorman, Long and Co., Limited), Mr. F. Mills (Ebbw Vale Steel, Iron and Coal Company), Mr. H. Steel (Frodingham Iron and Steel Company), Mr. E. Steer (Guest, Keen and Nettlefolds, Limited), Mr. H. Hall (Palmer's Shipbuilding and Iron Company), Mr. F. W. Cooper (Partington Steel and Iron Company), Mr. W. Thorneycroft (Steel Company of Scotland), Mr. G. A. Mitchell (Stewarts and Lloyds, Limited), and Mr. W. H. Hewlett (Wigan Coal and Iron Company).

Speaking at the recent annual meeting of the Barrow Hematite Steel Company, Limited, Mr. G. Mure Ritchie said that during 1917 the output of pig-iron had been larger than in any previous war year, but owing to the action of the authorities their large Bessemer plant had not been operated since the beginning of the war, and the bulk of the pig-iron the company produced was sent to competitive steel firms. He was pleased, however, to inform the meeting that the company had acquired some large iron-ore interests in Cumberland. Less than a year ago they had spent 150,000*l.* in acquiring a large interest in the Alcoats Company, and they were interested in some further large areas in Cumberland likely to contain iron ore. The board found it a matter of prime policy to get their blast-furnace plant modernised. Two modern furnaces were built a few years ago, and another new one was well on the way towards completion, and should be finished in three months' time. Assuming that these blast furnaces improvements could be carried out, the company would save many thousands of pounds per annum. Improvements were also being made in the steel plant. Unfortunately the scarcity of labour had interfered with the production of coal from their collieries near Barnsley, as last year they had only obtained 400,000 tons. Owing to the interference of the Home Office, and the never-ending demands of the trade unions, coal showed little or no profit to the shareholder.

The eighteenth annual general meeting of the British Westinghouse Electric and Manufacturing Company, Limited, was held in London last Monday, when Mr. J. Annan Bryce, M.P., the chairman, stated that in regard to the diminished profit of the year 1917, the main causes had been those which he had foreshadowed in his speeches since the war began, and the cumulative effects of which had become more marked as time went on. The labour position had become steadily worse. Not only was it exceedingly difficult to obtain labour at all, but that which was obtained was not so efficient, while the cost of it had risen immensely. The difficulties, which had been particularly acute during 1917, seemed likely to continue. Since May of last year there had been a constant drain on their labour resources through the combing-out of semi-skilled and unskilled labour under the scheme of the Ministry of Munitions. Further depletions had been caused by the recall to the colours of men returned from the army for munitions work, and the company expected that their shops would be still further denuded by the calls of the military authorities under the revised schedules of protected occupations and under the Man-Power Act. Great difficulty was experienced in making good these losses owing to the all-round shortage of labour of the class required. Every possible effort had been and was being made to fill the gaps by discharged soldiers, but this source of supply did not furnish nearly enough men accustomed to the company's class of work. The difficulties might be gathered from the fact that since January 1, 1917, to April 26, 1918, there were engaged 2,931 men and 2,506 women. As regards cost of labour, that of male labour was now 66 per cent. and that of female labour 100 per cent. above the cost in 1913, and these figures applied in the case of both sexes to the earnings of persons under 21 years of age as well as to those of persons above that age.

Mr. Bryce added that three gentlemen had joined the Board, representing the new financial interest—namely, Sir Ernest V. Hiley, K.B.E., and Mr. Lincoln Chandler, of the Metropolitan Carriage, Wagon and Finance Company, Limited (the latter one of its managing directors), and Sir Francis H. Barker, of Messrs. Vickers, Limited. The two former gentlemen had been elected by the board vice-chairman and managing director respectively. The abilities of all three gentlemen were well known in the industrial world, and he felt confident that with their experience and the support of the powerful concerns they represented a great future was in store for the company.

With regard to the arrangement made with the two firms referred to, it was not possible yet to say what the results would be, but everything tended to show that their assistance and support would be of the greatest possible advantage to the British Westinghouse Company.

A discussion on the allowance made by the Income-Tax Commissioners for depreciation of machinery took place on the Budget resolutions in the House of Commons on May 1. The following are the main points extracted from the official report:—

Mr. G. Terrell moved that the allowance should be "the amount which would be deducted by a prudent owner desirous of maintaining his business in a state of efficiency." As the law stands the Commissioners fix such a figure for depreciation as in their discretion they consider right. There is nothing to control them or indicate how they are to exercise that discretion. That has been the practice for forty years, and they have never allowed sufficient on machinery or on buildings, patents or goodwill. Manufacturers have no desire to evade taxation, or quarrel with the rate of income-tax or excess profits tax; but to tax a sum in excess of income is a tax on capital and is unfair. Lord Balfour of Burleigh's Departmental Committees have reported on this question. The Textile Trades Committee report in favour of larger allowances. The Shipping and Shipbuilding Committee report that often the allowance is only half enough. The Iron and Steel Trades Committee report that the allowances should be increased and calculated on the efficient working life of plant and machinery. The Engineering Trades Committee report that the existing rates of 5 per cent. to 7½ per cent. are too low and recommend 10 per cent. for day use and 15 per cent. for day and night use of machinery; and urge that immediate steps should be taken. The Government have had these reports for five months, but in their new White Paper they stick to the old system of forty years ago. Hitherto no allowance has been made upon workshop buildings—a matter which should interest the Labour party. If an owner sets up a fund, that fund is taxed and he can only get one-sixth of the rack rent value for repairs. This matter is very urgent and pressing, and the inaction of the Government up to the present has been a great disappointment.

Sir A. Williamson said the Treasury allow 5 per cent. on the written-down value of plant and machinery; 7½ per cent. on flour-milling machinery; 10 per cent. on gas meters, cookers and fires. The fact that machinery is driven more rapidly brings about more rapid depreciation. The policy of the Government discourages manufacturers from scrapping plant.

Mr. Bonar Law stated that the Treasury has no powers to grant this relief. It is done by the Commissioners of Taxes, who are independent of the Treasury. Mr. Bonar Law added: "We cannot give them orders. It is quite true that, to a large extent, they take advice from the Treasury, but in particular districts there are people who might, and sometimes do, take an entirely different view from the Treasury and, if so, we have no redress. We simply have to accept their view. I pointed out last year that the custom now is that if manufacturers desire to scrap machinery the Commissioners give them credit, for the full value, less the scrap value." Challenged on this point by Mr. J. Henderson, Mr. Bonar Law continued: "My advisers tell me it is invariably so, and if not there is a right of appeal. Mr. Terrell said, 'as a prudent owner would think right.' What does that mean? Some directors want to make a good show and give big dividends, others write-off a very large amount. The Bank of England as a prudent owner has written down the value of the ground on which the bank stands to 5*l.*"

Mr. J. Mason, Sir C. Henry, Mr. J. Henderson, Sir W. Pearce, Sir Norval Helme, Sir J. Walton, and Sir C. Cory spoke in support of Mr. G. Terrell's amendment. There were no speeches against. The amendment was rejected, the voting being: Ayes, 40; Noes, 110.

QUENCHING LIQUIDS.—The quenching liquid for steel, reports *Machinery*, New York, should cool the piece readily without being so harsh as to cause a rupture of the fibres. When hot steel is continually dumped into a tank of oil, the lighter and volatile oils are evaporated and finally only the heavier oils will be left. When the oil becomes thick, it will not take the heat away from the steel rapidly; consequently, the steel will be soft and will not show the maximum physical properties. To obtain good results, the quenching liquid should be of a constant specific gravity and maintained at a temperature of 70 deg. to 90 deg., but the exact temperature at which the bath is maintained does not matter so much if it is always the same. To insure the best results, the bath should always be maintained at a certain specific gravity and at some certain temperature.

SCIENTIFIC UNREST.

TO THE EDITOR OF ENGINEERING.

SIR,—The strictures you give expression to in the current issue of your esteemed journal are very appropriate, but I trust you will accept a few remarks from one who has had occasion to witness many of the phenomena you allude to, and has his own ideas as to the interdependence of at least some of them.

There can be no doubt that the private student finds himself time after time up against the professional element, which latter in many cases directly controls the incumbent scientific publications. In these publications it is quite a familiar sight to meet with, to find Professors X., Y., and Z. mutually referring to each other's work and views, sometimes even just advertise their respective doings, and it is by no means infrequent to observe, that the whole quibble is about something which has been observed and reported by a rank outsider to their mutual admiration clique. It is, of course, very easy for the professional ring to effect such exclusiveness, but from the point of view of the "popular scientist" afflicted with "*scientific unrest*" the professional attitude is bound to resemble sometimes a somewhat dishonest one. I have met with cases where professional parties were made specially aware of work done previously to them by the "*popular scientist*," but that made no impression on the supine professional mind, which could not be induced, even in face of the facts of the case, to as much as mention the name of the outsider in his subsequent discussions on his great discovery, which conduct I have no hesitation from setting down to scientific plagiarism. The maximum concession to be obtained from such individuals is the unavoidable recital of possible names of workers prior to their "lime-light" performance, which have been honoured by entry in the incumbent text-books, and which they, therefore, did not dare to skip and delete.

Again, text-books are written and issued wholesale very carelessly, and the reviews accompanying them are, I believe from fear of the entry of the overstrained libel-laws, by a long way not severe enough in many cases, if adverse at all or even critical, and instead of relentlessly challenging the "stuff," errors are neither discovered, nor exposed, nor eliminated. No wonder some people are becoming rather sceptical when they behold the dogmatic, and then sometimes amusing, attitude of some of our would-be authorities. Amongst others, I have in mind a greatly admired scientific publication of which I possess three successive impressions. Remarkable to relate, obvious errors attaching to the first issue, and, in a sense, excusable there, we find reprinted up-to-date, solely due, no doubt, to rank carelessness of the printers and reviewers. Or do our "authorities" wish to teach deliberately the students and readers how to perpetuate mistakes, or are they so enshrouded in their dogmatic cocksureness, that they deem it not worth their trouble to subject their writings to severe review and criticism themselves?

As to keeping in the lime-light, readers of scientific papers, books, lectures, &c., &c., must indeed become strongly aware that some of the teachers of the popular scientist indeed are given to this mania somewhat immoderately, with the necessary consequence, that we are deprived of the expression of opinion by their more modest colleagues, who may know more and know it better than some of these exclusive occupants of the scientific stage.

Very respectfully yours,
ALBERT ALFRED BUSS.

22, Egerton-road, Chorlton-cum-Hardy, Manchester.
May 6, 1918.

THE MILITARY AUTHORITIES AND ENGINEERS.

TO THE EDITOR OF ENGINEERING.

SIR,—The letter of April 26, 1918, signed "Eighteen Corporate Members," published on page 468 of your issue of April 26, has my support. It is not easy for a civil engineer to obtain the right to add M. Inst. C.E. to his signature, but when he has, it appears to have no weight with the military authorities, neither can it be relied upon to obtain him a commission in any branch of the army.

Any qualified medical man can obtain a commission in the Royal Army Medical Corps, with adequate pay and certain promotion at fixed intervals. A corporate member of the Institution of Civil Engineers should be able to do the same in the Royal Engineers, and with advantage to the nation; for aerodromes, large standing camps with their sanitation, railways, munition, and other works would be better designed and more economically constructed by civil engineers.

If the members of the council would visit some of these places up and down the country, they would see the results of the square-peg-in-the-round-hole system, and be able to formulate proposals for its improvement, which the Institution should support in the proper quarter.

I enclose my card, and am,
Yours faithfully,
"ANOTHER CORPORATE MEMBER."
(Serving as an Infantry Subaltern.)

THE CANAL QUESTION.

TO THE EDITOR OF ENGINEERING.

SIR,—The superficial habit of thought, and lack of thoroughness, of the average Briton is at no time more evident than when he discourses on the canal question. The railway enthusiast will tell you that a railway can "knock spots off" a canal, for any kind of traffic you like to name, and backs up his assertion with instances of canal traffic having been captured; but he has not taken the trouble to think out, and formulate, the reasons for the results he quotes, or to consider whether railway competition with a canal of a different class and type would have had a different result.

Quite recently the provost of an important East Coast town gravely advanced the argument: That, because canals in England had been killed by railway competition, the proposed Mid-Scotland Ship Canal was doomed to be a failure; and more recently still, a correspondent signing himself "Punter," in a letter published in your issue of April 19, comes to the conclusion that all canal enterprises are futile, because, although the Thames has been canalised, he "can spend a whole day there without seeing a barge in motion."

On the other hand, the statements of the canal partisan are quite as reckless. He will tell you that the country is "going to the dogs" because of its criminal neglect of inland waterways, and its shortsighted folly in allowing railway companies to become owners of canals; but he cannot prove that any canal, that has been acquired by a railway, would have fared any better if it had remained in the hands of its previous owners; and, if you ask him what exactly ought to have been done to our "inland waterways," he can only generalise, and say that they ought to have been nationalised.

Such general conclusions, based on the assumption that all canals are of the same type and class, are of no value whatever, because the assumption is quite erroneous. Between the small inland barge canal with no outlet, or no direct outlet, to the sea, at one end of the list, and the sea-to-sea ship canal at the other end, there are various intermediate types, and with each type the conditions for successful working vary, not only with the type, but also, in each individual case, with the character of the districts to be served.

With regard to the first type mentioned—when roads were poor, and railways and motor vehicles non-existent, the small inland barge canal served a useful purpose, and offered the most economical means of transport then available; but since the advent of improved land transport, one cannot but admit that, in the majority of cases, the little barge canal has outlived its usefulness.

If additional means of transport between two inland centres were needed to-day it is quite certain that no one would think of constructing a new barge canal for the purpose; because the material to be transported being already on land, and having to be delivered on land, its conveyance by water would still entail *some* land transport at one end, if not at both ends; and because, in the matter of collection and delivery, a barge is much less convenient than a motor van or a railway truck. Suppose for a moment that the owner of a large works, with a barge canal on one side and a railway on the other, were given the option of having led into his works either a branch from the canal, or a siding from the railway, but not both; is it conceivable that he would select the canal, when the siding would give a connection with practically every town and seaport in the kingdom? One may safely conclude therefore that, when material has to be moved from one inland place to another inland place, transport by land will nearly always be more convenient and more economical than transport by barge canal.

The type of canal at the other end of the list, viz., the sea-to-sea ship canal, occupies quite a different position, since there is no possibility of successful competition by any form of land transport. In the case of through traffic it is obvious that competition is impossible; and for intermediate traffic, any form of land transport would be handicapped by the cost of breaking bulk and double handling, and would be hopelessly outclassed.

We have thus, at one end of the list, a canal offering facilities inferior to those of modern land transport, and, at the other, a canal that no form of land transport can compete with; and the main difference between the two canals, apart from dimensions of waterway, is that one can efficiently deal with sea-borne traffic, and the other cannot. It would thus appear that the ability to accommodate sea-borne traffic should be the criterion for *all* types of canals and waterways intermediate between the two I have mentioned.

It is evident that this must be so, for if, as I have already shown, the conveyance of goods *by water* from one inland place to another inland place is out of date, the two main functions left for canals to perform are: (1) To pass seaborne traffic from one sea to another, and (2) to pass seaborne traffic between the sea and an inland industrial centre. So that when considering any proposal to construct a new canal, or to improve and enlarge an existing canal, four questions will practically cover all the ground, viz.:—

1. Will the canal adequately accommodate seaborne sea-to-sea traffic?

2. Will the canal convey seaborne traffic without break of bulk to its inland destination, or near thereto, and *vice versa*?

3. If seaborne traffic has to be transhipped for passage over the canal, are the conditions such as to render transhipment into, and distribution by, self-propelled barges, more efficient than direct transfer from the sea-going vessel to the railway at seaport would be?

4. Will there be sufficient traffic to give a return on capital expended, after providing for cost of maintenance and working?

If either of the first three questions, in addition to the fourth, can be answered with certainty in the affirmative, there is *prima facie* a good case for a canal; otherwise, there is not.

I notice a second letter from your correspondent "Punter," but, as applied to canals in general, it is of no more use than his first. His statement that the Upper Thames "is as good a waterway as there is in the country" is certainly incorrect. Compared with the Clyde between Greenock and Glasgow, which is nothing else than a shallow river converted into a ship canal, it is simply nowhere at all. On the Clyde, sea-going vessels carry bulk cargoes right to their destination, whilst for the Upper Thames everything has to be transhipped into small barges. "Punter" may be quite correct in suggesting that it would not pay to provide larger locks and a deeper channel up to Oxford, but the last sentence of his letter shows that he has not appreciated the reason why. If Oxford, instead of being what it is, were the centre of a large and populous manufacturing district (like Manchester for instance), and there were *then* no barges to be seen in motion, there might possibly be some force in his argument; but, from my slight acquaintance with the Thames above Windsor. I should think there would be very little demand for the kind of traffic that could profitably be conveyed by water, so that I am not surprised to hear that the river is chiefly used for pleasure purposes.

Yours faithfully,
L. JOHN GROVES,
(Engineer, Caledonian and Crinan Canals.)
May 7, 1918.

TO THE EDITOR OF ENGINEERING.

SIR,—I much appreciated "Punter's" letter, which appeared in your issue of the 3rd inst. You will not want this correspondence extended, so I will be extremely brief. The complaints I referred to in my letter of April 24 are not made direct to the bargees, but are constantly made in writing to the Thames Conservancy. The Thames Conservancy certainly know their business. The dictionary says to conserve is to "guard from violation."

"Punter" makes a strong point about a commercial man saying if he had greater facilities he would do better, but I think he has missed the point in referring to capital charges. In lighterage work by far and away the biggest account is labour. The labour is the same for a 60-ton barge as for a 200-ton barge. Consequently below Teddington there are thousands of big barges which cannot be used above Teddington. Therefore the capital charge on up-river work is comparatively high, and the 60-ton barge below Teddington is not large enough for the work. If, however, a barge loaded at Tilbury could go through to Oxford the arrangement would be efficient.

It is lack of this efficiency, owing to the inability to carry a proper load in relation to standing capital charges, so far as labour is concerned, which in my opinion keeps back the Thames and the canals.

Yours faithfully,
(For Perman and Co., Limited),
A. PERMAN.

82-83, Fenchurch-street, London, E.C.,
May 8, 1918.

ELECTRICITY *versus* GAS AND COAL FOR DOMESTIC USE.

TO THE EDITOR OF ENGINEERING.

SIR,—The cost of thermal units, delivered electrically to the consumer, is so high as to render Mr. Jude's arguments apparently incontrovertible. Yet there are cases where he is wrong. Let me quote my own experience. I work many hours over a drawing board and have suffered intensely from cold fingers during last winter. Warmer clothing made matters worse by reducing the circulation of blood. A bright gas fire warmed my legs to an uncomfortable degree and blistered the varnish on the table legs, but left my hands numb and cold, although the consumption of gas amounted to 2*s.* per day. By placing an electric heater, in the form of a large flat pad, under the drawing board, I have succeeded in keeping my hands warm, with an expenditure of 2*d.* per day. It is true that my feet were cold on several days, but another pad on the floor has cured that trouble at a cost of an additional 2*d.* per day. The advantage in using electrically-produced thermal units lies in the fact of their being delivered where they are wanted.

Yours truly,
EDWARD C. BARTON.

ELECTRIC POWER SUPPLY AND COAL CONSERVATION.

TO THE EDITOR OF ENGINEERING.

SIR,—The discussions which have taken place *re* the report of the sub-committee on the above subject appear to have been confined—to a large extent—to the electrical engineers, whilst the ordinary steam user has not made himself heard.

In many works and other buildings there is a large demand for steam for process work, &c., whilst practically all works require steam or other forms of heat in the winter time. A small power plant can be installed in conjunction with the other steam plant and the exhaust steam utilised, the economy effected by this combination being such that no form of central supply can compete with it. I am familiar with two buildings of the same nature and capacity, in one of which the electricity is generated on the premises and in the other, obtained from a central supply; the coal consumption in the two buildings is the same, whilst in the second case the cost of electricity has to be added. The engineering staff of the two buildings is the same.

I think that if this method of supply were extended to its fullest extent by the grouping of suitable adjacent buildings to one steam plant and the utilisation of exhaust steam for general heating purposes, the total economy effected would be considerably in excess of that obtained by the adoption of super-power stations, whilst the first cost would be much less.

Yours faithfully,
May 1, 1918. J.

THE IMPORTANCE OF COKE HARDNESS.*

By G. D. COCHRANE, Middlesbrough.

When I accepted the invitation to read this paper, I hoped to be able to devote a considerable amount of time to its preparation and to the collection of information and experiments of a practical and scientific nature bearing upon the subject, but it has only been with great difficulty that I have managed to find time to write the following lines.

Fig. 1. MACHINE FOR TESTING THE HARDNESS OF COKE

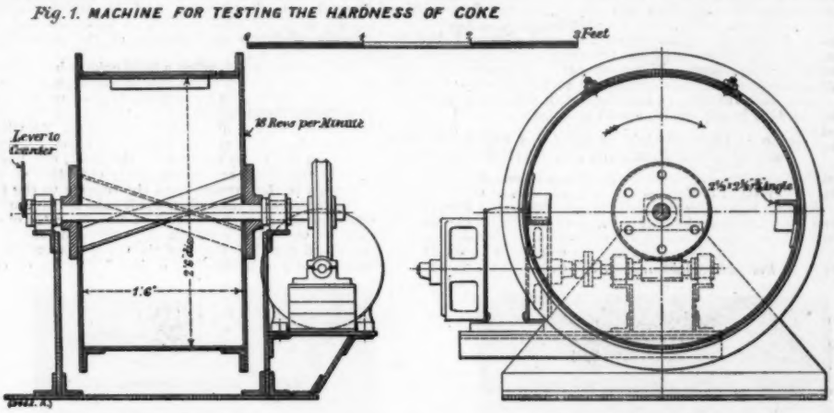
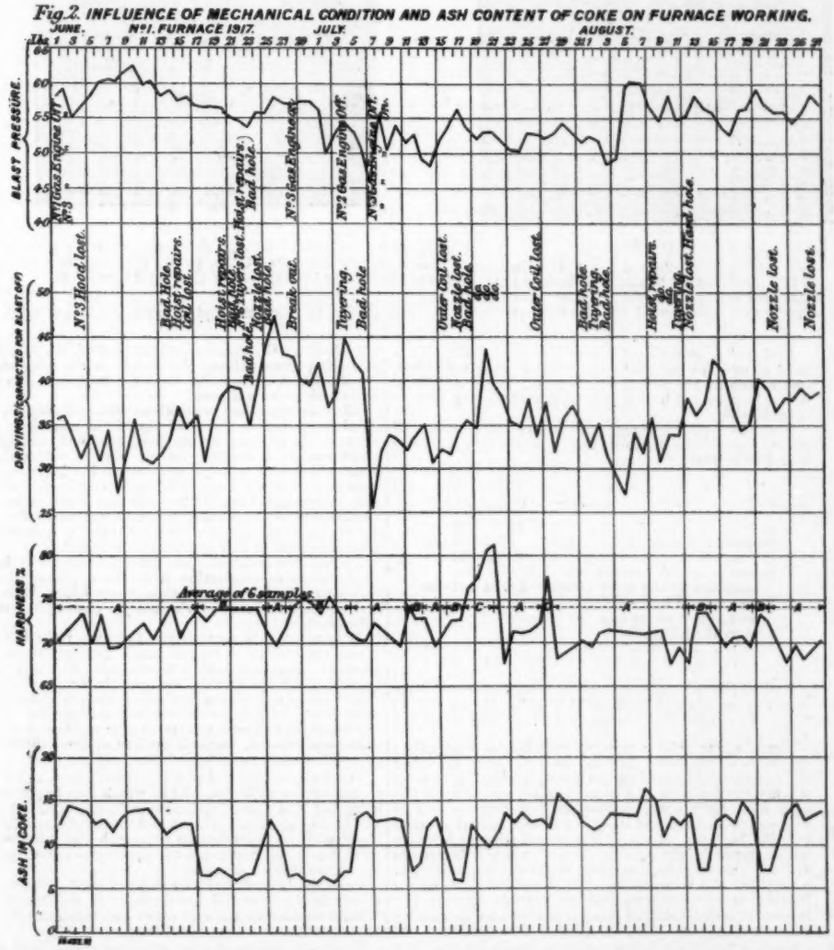


Fig. 2. INFLUENCE OF MECHANICAL CONDITION AND ASH CONTENT OF COKE ON FURNACE WORKING.



It has been no easy matter to keep my remarks within the scope of the blast-furnace plant, as the onus of the manufacture of the coke is with the coke-oven manager, and it is to him the blast-furnace manager has to look for the regularity and quality of his supplies. It, therefore, is no uncommon occurrence to find that the chief concern of the coke-oven manager is to get as large a percentage of coke and by-products from his ovens as possible and, so long as those percentages are satisfactory, to pay little attention to the mechanical condition of the coke made, with the result that the blast furnace suffers.

I propose laying down an axiom and supporting it by a few facts that have come to my notice during the past few years, and when I have finished you may criticise my argument but not convince me against it. It is this: "The practical success of the working of a blast furnace is chiefly dependent on the mechanical condition of the coke used." This may appear to be a somewhat sweeping assertion, but I will endeavour to warrant it, subject to the reservation that the mechanical portion of the plant is in good average working condition. There is no doubt that the question of the mechanical condition of the coke is a very controversial subject, but it has not received in the past anything like the amount of attention and investigation that its importance in blast-furnace practice calls for, and it is with the object of calling attention to this lack of information on the subject that this paper is written.

I have ignored the mechanical and chemical conditions of the ores and fluxes, as, when making Cleveland iron, it will be agreed that there is practically no variation therein from one year's end to another.

The percentage of ash in the coke and the analysis of the ash are factors that are more variable, which affect the coke consumption per ton of pig-iron and the quality of iron directly, but are capable of anticipation and calculation. The coke hardness is a thing apart, and in my experience can be treated as such, although I fully recognise that it has its chemical actions and reactions to perform in the furnace, apart from its purely mechanical functions.

Since I shall frequently refer to the "hardness of the coke," it is necessary for me to explain the meaning of the term.

In 1909 we installed a machine which was called the coke tester, and which was originated, I believe, by Mr. Greville Jones, of the Clarence Ironworks, Middlesbrough. As a practical experiment it was a success, inasmuch as we were enabled to say whether a coke was good, bad, or indifferent, from the hardness point of view, for utilisation in the blast furnace.

As you will see by the accompanying diagram, Fig. 1, it is of very simple design. It consists of a drum which is made to revolve at 18 r.p.m., with two angle bars fixed inside to turn the coke over; there is also a hand hole for insertion and extraction of the coke sample, and an indicator to note the revolutions.

To make a test for hardness a sample of coke is taken of about 56 lb. weight, consisting of lumps up to the size of one's fist, and dried on hot plates for 24 hours. Of this 28 lb. are weighed out and placed in the drum, and the cover plate screwed down. The drum is then revolved for 1,000 revolutions at 18 r.p.m. The coke is next taken out and riddled over a ½-in. mesh, and that which remains on the riddle is weighed and the percentage of the original 28 lb. noted. That percentage we call the "hardness" of the coke.

By this means, after a few months I had a good comparative record, and by closely watching and comparing the furnace drivings with the coke hardness, I found that there was a very close connection between the two. I need not relate the detail which was gone through to eliminate every possible cause that might have misled us into believing the variations in the drivings were caused by the coke when the source of trouble lay elsewhere; it is sufficient for me to tell you that every care and precaution were taken, and we were eventually convinced that the coke, and that alone, was responsible for the variations in the drivings.

The next item to determine was at what point on the coke hardness scale the drivings commenced to fall off; this was found to lie between 74 per cent. and 74½ per cent. of hardness, and during the past eight years this has been proved correct on so many occasions that I do not hesitate to say that in connection with our own plant we know there will be slow driving and consequent trouble when the hardness falls below that percentage. It is therefore essential, if we require good steady driving, that the coke hardness should be over 74 per cent.

I have not been able to trace any additional advantage with coke of a higher percentage of hardness than 76 per cent., but on plants where a blast pressure in excess of 7 lb. per square inch is used or available, it may be found that the benefits derived from a hard coke may accrue to a higher percentage than I have mentioned.

When the hardness falls below 74 per cent. a very marked falling-off in the drivings takes place, and I find that the lower the percentage the worse are the drivings. I have had the experience during the past twelve months of using a considerable quantity of coke which has only averaged 70·5 per cent. of hardness, and I estimate that as a direct result the drivings of the blast furnaces have fallen 20 per cent. I do not, however, care to state definitely that percentage as, due to mechanical troubles with the blowing plant, the blast has been very variable, and it is extremely difficult to apportion the blame correctly, but from past experience I do not think I am far out in my estimate.

The diagrams of coke hardness and drivings (Fig. 2) which I kept for a few weeks last summer are extremely instructive, and illustrate the immediate increase of drivings which follows on the charging of a hard coke; there is nothing of which I know that appeals to the eye and the brain so readily as a diagram such as this, and I place a great deal of confidence in it to support my axiom that "The practical success of the working of a blast furnace is chiefly dependent on the mechanical condition of the coke used."

It is unfortunate that the period covered by these diagrams should have been one in which the blast pressure was very variable, and I think I should call attention to the fact that the blast line shown is only the average for the 24 hours, and consequently does not indicate those periods during the daytime when the pressure sometimes fell to 3 lb. and even less for 4 hours or 5 hours at a time.

The drivings are corrected for the time the blast was off the furnace each day—that is to say, if the blast was off for 1 hour and the drivings were 30 for 23 hours, then 30/23 = 1·3 rounds per hour, therefore 30 plus 1·3 = 31·3 rounds for 24 hours. The hardness percentages are the daily tests and represent one sample only per day. There were three different cokes used during this period, marked, A, B, and C; the B coke has a very low percentage of ash, and although not hard is less friable than a coke containing a higher percentage of ash, owing to it not being so much split up by small pieces of stone. Consequently it acts up to a point in the same manner as if it were 1 per cent. or 2 per cent. harder.

Another point I wish to mention is that with a 76 per cent. hardness coke, and an average ash contents of 12·5 per cent., the daily drivings of the furnace to which these diagrams refer is 48 rounds per 24 hours, with no

* Paper read before the Iron and Steel Institute, Thursday, May 2, 1918.

allowance made for blast off, but with a pressure of 6½ lb. per square inch.

It will be noticed that although the diagrams are chiefly below par, i.e., 74 per cent., immediately that critical degree of hardness is passed a marked improvement in the drivings is immediately indicated, in spite of outside adverse factors appearing here and there.

I have now stated roughly the general effect on a blast furnace when using hard and soft coke. When the former is used increased drivings give greater output and, conversely, when the latter is used reduced drivings mean a smaller make.

This leads naturally to the question of coke consumption, and I will now attempt to show the advantage of hard coke in this respect.

When coke is charged into a blast furnace it immediately comes into contact with the ascending gases, which act upon it in a greater or lesser degree, dependent upon its mechanical condition and the temperature of the gases.

Many experiments have been carried out in the laboratory with a view to illustrating this reaction, and it has always been found that the gases have far less effect on hard coke.

Bell, in his book on the "Manufacture of Iron and Steel," gives the following experiments, which indicate a serious loss of carbon when using soft coke :

"Trials of coke from two different collieries—the one being of known inferiority to the other—for decomposition of CO_2.

"The specimens were exposed side by side for different periods of time at a temperature of about 1,500 deg. F. (815 deg. C.) :—

Exposure.	Average of	Percentage of Loss. A (better quality).	Percentage of Loss. B (second quality).	Ratio of A to B.
hours.				
2	3 samples	1·097	2·257	100 205
4	3 ,,	1·903	3·767	100 198
6	2 ,,	2·904	5·645	100 194
8	1 ,,	3·893	7·801	100 200
			Average	100 199

"These trials therefore indicate that while a ton of coke in the case of A would in 2 hours lose 0·778 cwt., the waste on B would be equal to 1·560 cwt.

"A second series gave the following results :—

Exposure.	Average of	Percentage of Loss. A (better quality).	Percentage of Loss. B (second quality).	Ratio of A to B.
hours.				
2	2 samples	0·758	2·274	100 300
4	2 ,,	1·356	3·152	100 233
6	2 ,,	2·674	5·766	100 215
8	2 ,,	3·892	7·802	100 200
			Average	100 237

"Both sets of figures indicate that the better quality coke continued at the end of 8 hours less susceptible to the action of hot carbonic acid than the other with which it was compared."

In another part of the same work he says : "The mechanical texture, however, of the coke is perhaps more important in the eyes of the furnace managers than any trifling increase in the percentage of ash"; also, "In addition to the experiments already given specimens of coke were exposed at a bright red heat (1,560 deg. to 1,580 deg. F.) for the same time to the action of a current of carbonic acid. In the case of the soft coke 18·7 per cent. of the carbon in the carbonic acid was reduced to the state of carbonic oxide, while in that of the hard coke the proportion of carbon so altered was only 7·3 per cent. of the total quantity."

It is therefore quite evident from Bell's writings that he was fully aware of the evil effects of soft coke in the blast furnace, and gives that opinion great weight by the experiments just quoted.

Charles Cochrane also refers to the importance of retaining as much as possible of the carbon in the waste gases in the form of carbonic acid, but does not directly mention it in connection with soft coke. He says :—

"It will be seen how important it is, with regard to economy of fuel in a blast furnace, that we should ensure the combustion of every unit of carbon, if possible, into the more highly oxidised gas called carbonic acid; and furthermore, when once burnt into carbonic acid, that we should never allow it to pass again into the condition of carbonic oxide, if such a step be preventable."

Following on the lines indicated above, I had an experiment made in the Ormesby Laboratory with the following result. Pieces of hard and soft coke were placed in crucibles containing carbonate of lime which supplied the CO_2 and covered with lids and placed side by side in the muffle for 45 minutes :—

Action of Carbonic Acid on Hard and Soft Coke. Test made at a Red Heat. 705 deg. C. (1,382 deg. F.).

	Hard Coke. Grammes.	Soft Coke. Grammes.
Weight of Coke—		
Before test	13·834	11·610
After test	13·713	11·243
	0·121	0·367
Percentage loss	0.88	3.16

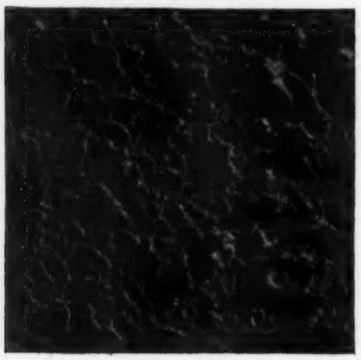


FIG. 1.—Hard Coke.

Ash, 13·7% ; Sulphur, 1·31% ; Hardness, 75·67% ; per cent. of Water absorbed by Dry Coke, 30·49 ; per cent. of Loss when heated to redness in a current of CO_2 for 2 hrs., 5·40

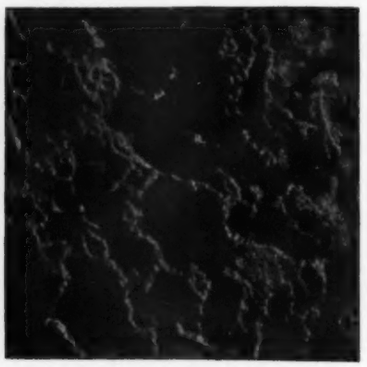


FIG. 2.—Very Soft Coke.

Ash, 12·50% ; Sulphur, 1·16% ; Hardness, 54·48% ; per cent. of Water absorbed by Dry Coke, 51·09 ; per cent. of Loss when heated to redness in a current of CO_2 for 2 hrs., 9·70

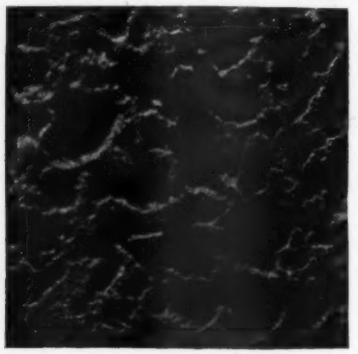


FIG. 3.—Soft Coke.

Ash, 12·0% ; Sulphur, 1·22% ; Hardness, 68·08% ; per cent. of Water absorbed by Dry Coke, 39·26 ; per cent. of Loss when heated to redness in a current of CO_2 for 2 hours, 7·01.

Magnified 15 diameters, and reduced by one-quarter.

It therefore seems to be conclusively proved that if a coke of over 74 per cent. hardness is used very little loss occurs at the top of the furnace, but if a coke of below 74 per cent. hardness is used the loss may be very considerable.

The three photomicrographs (above) were taken of picked specimens of coke and subjected to the tests attached to them :—

	Hard Coke.	Soft Coke.	Very Soft Coke.
Ash	13·7	12·0	12·50
Sulphur...	1·31	1·22	1·16
Hardness	75·67	68·08	54·48
Percentage of water absorbed by dry coke	30·49	39·26	51·09
Percentage of loss when heated to redness in a current of CO_2, for 2 hours, 750 deg. C. (1,382 deg. F.) ...	5·40	7·01	9·70

I think the photographs taken in conjunction with the tests require no further comment from me, the conclusion to be drawn therefrom being entirely in support of my argument.

Again a soft coke is usually very friable, and unless the ovens are situated close to the blast furnace, so that the minimum of handling is thereby assured, it usually reaches the furnaces in a much smaller form than is the case with hard coke, consequently a greater area is exposed to the action of the gases as soon as it is charged into the furnace. (I am, of course, referring to furnaces with comparatively small makes, as when a furnace is making 700 tons a day, as many are in the United States, a smaller coke is necessary, but it must still be hard.) Having therefore commenced its passage through the furnace in a small state, I think it is allowable to imagine it becoming very finely divided before reaching the melting zone, and in support of this theory I should like to tell you of my experience at the Ormesby furnaces.

Trouble had been experienced at one of the coke-oven plants from which our coke supplies came, and the coke that was being charged into the furnace was soft and friable, and altogether what I should term very bad indeed. The furnaces struggled along for a few days, gradually driving slower and slower, until the coke commenced to improve; but, owing to the poor coke, the drivings of one of the furnaces had become so slow that we feared she was commencing to hang, as we could not get the slag to run. So, taking out the front tuyeres, we blew forward for a while to try and clear the forepart. This solved our troubles, for on commencing to blow forward great clouds of fine cokedust were blown out, and when this ceased the front tuyeres were replaced, and the furnace commenced to drive again quite freely and, with the better coke coming down, we had no further trouble with the drawing off of the slag. This has occurred more than once, and is just one more instance of the terribly bad effect of soft coke on the blast furnace. Although this may be an extreme case, it serves my purpose to show that a low coke consumption cannot be expected when the coke loses some 10 per cent. or 15 per cent. of its weight within 2 hours or 3 hours of being charged into the furnace, and on arriving near the tuyeres is in the form of dust so finely divided that it actually obstructs the passage of the blast and the tapping of the slag.

On the other hand, when a hard coke is being charged, there is only a very small loss at the furnace top; the lumps of coke are larger and less friable, with the result that the burthen is kept open and the blast passes through the furnace with a minimum of resistance. So, when the coke reaches the tuyeres, there is a considerable body of carbon left to be reduced by the blast, and the gases evolved therefrom are consequently operative on all the materials in the furnace from the tuyeres to the throat.

It is noticeable that when a soft coke is being used the waste gases are very rich in CO, and the ratio of CO to CO_2 by weight is consequently low, whereas when a good hard coke is being used the CO is less and the ratio consequently considerably higher. This is, of course, explained by the greater ease with which the CO_2 in the ascending gases attacks the carbon of the coke when it is soft, which action the harder coke is able to resist in a much greater degree.

There is one other point about which I keep an open mind, and that is the crushing of the coke in a blast furnace. It is obvious that hard coke will offer greater resistance to a crushing stress than a soft one, but Charles Cochrane always said, when his huge furnaces were criticised and the possibility of crushing of materials was mentioned, that "The crushing effect in a blast-furnace can never be very great, owing to the fact that the theory of the angle of thrust is equally applicable to a blast furnace as it is to a grain elevator."

I have now touched upon what I consider to be the chief points in connection with the hardness of coke, and over a period of some eight years I have been time and again convinced of the unique importance of the coke hardness.

If hard coke is sent to the furnaces from the coke ovens the life of a blast-furnace manager becomes a pleasant thing, but with soft coke his life is not worth living. With the former one gets the furnaces driving freely, a low coke consumption, an even quality of iron with plenty of gas for stoves, boilers, and gas engines and to spare, and with the latter slow drivings, increased coke consumption, variable quality of iron, shortage of gas, and general trouble and discontent.

There are a thousand and one little points and details in connection with this subject which it is impossible to bring out in a short paper of this description, but all of which only go to prove more and more conclusively that if we wish to manufacture iron with the minimum of trouble and the maximum of economy it is on the coke the whole matter depends.

Since the blast-furnace manager in most cases is more or less in the hands of the manager of the coke ovens, it behoves him to try and make the managers of coke ovens produce and send him a hard coke.

Doubtless it can be done by "stamping," but there are not very many plants in this country that are fitted with that device. Also I do not think it is necessary to produce a coke of greater hardness than, say, 76½ per cent. for conditions such as I have taken as normal, although greater hardness means a larger margin of safety. Besides, I have used coke made from identically the same coal without "stamping," which has one day been excellent in every respect and a few days afterwards equally indifferent. It therefore appears to be chiefly a question of supervision, and I trust that this short paper of mine may attract the attention of the coke

producers to the importance of hard coke for blast-furnace work, for in that case I shall not have pleaded in vain that "The practical success of the working of a blast furnace is chiefly dependent on the mechanical condition of the coke used."

APPENDIX.

Since writing the paper a discussion, opened by Mr. Hewson, chief chemist of Messrs. Palmer's Shipbuilding and Iron Company, Limited, Jarrow, has taken place on the same subject at a meeting of the Newcastle Section of the Society of Chemical Industry.*

Mr. Hewson voiced the importance of hard coke for blast-furnace work, and said "the physical condition of the coke was as important as the chemical. The most important physical characteristic was the hardness or density which was a measure of its resistance to abrasion or crumbling." He also described a testing machine and the method employed in making a test, which corresponds closely to that used at Ormesby (described in the paper) save in one most important factor, and that is, he uses a perfectly plain drum with a dozen cast-iron balls inside of 1¼ in. diameter, which means that as the drum revolves the coke and the balls slide together over a perfectly smooth surface. Consequently very little breaking up or testing of the coke takes place, which I think is amply proved by the figures he gives, and so this test is inferior to the Ormesby test. I also consider that the pieces of coke with which he makes his test are too small.

Jarrow Test.—The sample (pieces of from ¼ in. to 1 in.) is sieved through a ¼-in. mesh. The coke remaining on the sieve is dried at 120 deg. C., and 28 lb. are weighed and placed in a drum or rattler, together with a dozen cast-iron balls 1¼ in. diameter. The drum is given 1,000 revolutions in about an hour, and the coke withdrawn and sieved on a ¼-in. mesh. What remains on the sieve is weighed and calculated to a percentage of original weight, and this gives the hardness number.

Comparison of Ormesby and Jarrow Tests.

Jarrow—	Lb.	oz.
Remaining on ¼-in. sieve	27	2
Passed through	0	14
Total	28	0

$\frac{27 \cdot 125 \times 100}{28}$ equals 96·9 hardness.

Ormesby—	Lb.	oz.
Remaining on ¼-in. sieve	21	0
Passed through	7	0
Total	28	0

$\frac{21 \cdot 0 \times 100}{28}$ equals 75·0 hardness.

Although the two methods of making the tests are so so similar, the resultant hardness percentages or numbers are widely divergent; but for comparative purposes the results have a nearly equal value, so much so that Mr. Hewson has discovered on his own scale of hardness that "coke below 94 per cent. hardness causes serious trouble in working and results in the furnace scaffolding or hanging and getting decidedly cold," which is practically identical with the conclusion I have arrived at by the aid of the lower scale in use at Ormesby. Now, although I am in agreement with his remarks on the importance of coke hardness, I submit, since the Ormesby test gives a wider scale of hardness with simpler selection of the coke sample to be tested, that it is of more practical value.

I have not the pleasure of Mr. Hewson's acquaintance; consequently, owing to the fact that our investigations have been carried on independently and apparently simultaneously and our conclusions so closely coincide, I feel, although perhaps I should refrain from saying so, that a very strong case has been made out for the importance of coke hardness in blast-furnace practice. If this is so then I dare to hope that the Iron and Steel Institute will take steps to recommend a standardised coke tester, either on the lines indicated or by some other method, for utilisation by all coke makers and coke users to whom the question of coke hardness is of importance.

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LABOUR IN ENGINEERING FACTORIES.

*The Efficient Utilisation of Labour in Engineering Factories. (With Special Reference to Women's Work.)**

By BEN. H. MORGAN, of London.

THE immense demand upon the resources of the engineering industry for the production of munitions of war has necessitated many changes in our industrial system in order to ensure the most advantageous employment of labour and material. A great expansion of productive capacity had to be brought about, and while, thanks to the Navy, the supply of raw materials proved no insuperable difficulty, the provision of the necessary labour to utilise those materials was a question which could not be solved so readily. The number of highly skilled craftsmen in the country was limited, and as such men cannot be improvised, it was essential to utilise their abilities in the most efficient manner, and to draw upon the general labour resources of the country for all work which could be carried on without the lengthy and specialised training of the all-round tradesmen. The only large reservoir of labour available was constituted of the women of the country, and thus force of circumstances brought about their general introduction into the engineering industry.

The wide employment of women in engineering works, and the engineering sense and capability that they have developed, are undoubtedly among the outstanding phenomena of the war. Not that there is anything new in the employment of women on engineering and allied work, for it is recorded, that half a century ago a firm in Birmingham employed, at one time, 2,000 women in its works. Generally speaking, however, their female labour was confined to rough and poorly-paid industries, such as the chain, nut and bolt, screw and rivet, and the small metal trades generally, though later women began to take a more intelligent part in the newer industries such as telephone and other instrument making, electrical work, cycles and motors.

Usually their more advanced work was confined to the operation of automatic and semi-automatic tools such as capstans, presses, drills, screw and gear-cutting machines producing repetition work and requiring little more than manipulative dexterity, though there were a few women in isolated shops doing skilled work on the centre lathe and at the fitting bench; indeed, in the works of a prominent member of this Institution women were employed on fitting work using micrometers and working to a half-thousandth of an inch, but this was an exceptional case.

Towards the end of 1914, however, when the country was faced with the necessity of enormously increasing its output of munitions after its skilled labour had been considerably depleted through the voluntary enlistment of large numbers of skilled men, a reconsideration of the conditions surrounding the possibility of a more general employment of women in engineering workshops had to be seriously considered. The first step in this direction was an attempt to employ them on shell production. It called forth a protest from the trade union concerned, but after conference with the Employers' Federation, led to an agreement known as the "Crayford Agreement," under which female labour was admitted for the first time into shell making, but restricted to the operation of machines engaged on repetition work of an unskilled character.

It was soon seen, however, that this concession did not meet the needs of the situation, and in December, 1914, another conference was held between the employers and the unions at which the employers suggested the general relaxation of trade-union rules and restrictions for the period of the war. No agreement resulted, and in February, 1915, the Government appointed the "Committee on Production." The result of this committee's recommendations was the "Shells and Fuses Agreement" by which women were allowed to do work which had been previously allotted only to skilled men.

Then questions of rates of pay, interpretation of clauses and other difficulties arose and threatened to become acute. To bring about the settlement of these Mr. Lloyd George called a conference with 33 principal trade unions in March, 1915, at the Treasury, which resulted in what we all know as "the Treasury Agreement." This Treasury Agreement may be said to be the first really constructive measure providing, subject to certain safeguards, for the suspension, during the war, of such trade-union restrictions on munitions work, as might interfere with or hinder maximum output, and the "Munitions of War Act" gave the force of the law to this suspension as far as regarded controlled establishments.

Dealing with the subject of increasing production of munitions in June, 1915, Mr. Lloyd George, then Minister of Munitions, said:—

"If all the skilled engineers in this country were turned on to produce what is required, if you brought back from the front every engineer who had been recruited, if you worked them to the utmost limits of human endurance, you have not got enough labour even then to produce all we are going to ask you to produce during the next few months. Therefore we must appeal to the patriotism of the unions of this country to relax these particular rules in order to eke out, as it were, the skill to make it go as far as it possibly can go."

The first public explanation, however, of the changes needed to make up for the insufficiency of skilled labour was given by Mr. Lloyd George at Bristol in September, 1915, in his famous "Mechanics' War" speech. When giving particulars of the bargain made with the trade unions, he said:—

"We want to turn the unskilled on to work which unskilled men and women can do just as well as the highly skilled so as to reserve the highly skilled for work that nobody can do except those who have great experience, training and skill."

That was probably the genesis of what is commonly known as dilution. The retention of the principle so clearly enunciated in the foregoing statement would, I think, all engineers will agree, be invaluable to British industry after the war, but where the Government have made pledges to organised labour, however disadvantageously they may operate in peace time, I know that engineers will be the last to break the word they gave at a time of national stress. On the other hand it is to be hoped that a time will come when the unions will consider the whole question from the point of view of the national interest and industrial efficiency as well as in the interests of the women who have given their labour so whole-heartedly throughout the war.

This speech was followed by the issue, by the Ministry of Munitions, of a letter of instruction to all controlled establishments in October, 1915, in which firms were requested:—

"To take immediate practical steps in accordance with the conditions described above to give effect to these proposals in your establishment; that is to say, to replace skilled men wherever possible by less skilled labour, men or women, to use the skilled men so released in order to work night shifts or work other machines in your establishment, and to make the surplus available for transfer elsewhere."

and also by the appointment, in the Ministry, of a committee to deal with the dilution of skilled labour for the period of the war. Their scheme, which was adopted, contained the following three principal features:—

(1) "The principle of the scheme is that no skilled man should be employed on work which can be done by semi-skilled or unskilled male or female labour.

(2) "The principle cannot be applied to all establishments in the same degree—for example, in a shop doing repetition work the scheme is generally applicable, whereas in a marine engineering or repairing works the scheme would be applicable only to a limited extent.

(3) "It will be necessary to have a special survey of shops by fully qualified technical inspectors so far as possible, specially conversant with the employment of semi-skilled and female labour, who could advise the Ministry on the extent to which the dilution should take place, and assist the employers in the process."

Many other considerations were involved in the report of the committee, but the three points given represent substantially the scheme adopted, and continued up to the present time, for supplementing the deficiency of skilled mechanics.

Objections to the Scheme.—Before proceeding to analyse results it may be opportune to note some of the difficulties met with in carrying out the scheme. First and foremost may be placed the objections of some of the rank and file of trade unionists to the infraction of their rules and customs, involved in a wider employment of women and unskilled male labour. The majority of the workers loyally adopted the spirit of the agreement, but in nearly every shop there were to be found men who could not appreciate the national issues involved, but secretly or openly opposed the introduction of women workers. These objections were generally swept away by visits and explanation of technical officers from the Ministry, but in some cases they could not be overcome, and patched up local agreements had to be made, which led to disputes and restlessness, owing to inequalities in the application of the committee's scheme in different parts of the country. Also the fear of making their own work unremunerative through an unfair adjustment of wages held many back from giving their co-operation. On the other hand, it may safely be said that the majority of the trade unionists gave the Ministry of Munitions their support, and it is due to their real in assisting in the training of the unskilled and in overcoming the very practical difficulties involved in closely subdividing operations to enable women to be employed, that so many are to-day engaged in engineering industries.

Probably the employment of women on munition work in engineering shops was delayed as much by the conservatism of employers as by the objections of the trade unionists. The employer is proverbially cautious and difficult to move, and the convulsion of the war has not materially affected these characteristics. It was difficult to persuade the trade unionist that women could do certain classes or so-called skilled work because he did not always want to believe it, but the employer often met dilution proposals with a blank incredulity which was beyond the influence or reach of reason. All kinds of means had to be adopted to bring him to a realisation of the real capacity of women workers.

The author particularly remembers his early efforts to put women on to the building of 3½-ton motor lorries while engaged firstly as a dilution officer and subsequently as technical adviser to the Labour Supply Department of the Ministry of Munitions. It was only after being treated as a humorist for a long time that he induced the management of the first works visited to train half-a-dozen women to perform certain operations. Going to the next works engaged on the same product he induced that firm to try a similar number of women on other operations. And so going from one works to another, always varying the operations, he got dilution under way. When the women in each shop had "made good" on particular operations photographs were taken and results recorded, from which the author was able to demonstrate that the bulk of the machinery work in this particular branch of industry could be successfully done by women. After that progress was very rapid.

Another method of overcoming the prejudice against the employment of unskilled labour was to provide a few workers for particular operations from the training

* Paper read before the Institution of Mechanical Engineers, Friday, May 3, 1918.

schools of the Ministry, in which some 40,000 persons have been trained. But perhaps the most effective antidotes to opposition were the distribution of the photographs referred to, the circulation of illustrated matter giving particulars of dilution examples and methods, the issue of process sheets setting out the actual work performed by women throughout the country in various products, the exhibition of examples of women's work in the principal industrial centres, and addresses to workers illustrated by cinematograph films These were some of the means used for showing both employers and workmen what women were capable of doing in the production of munitions.

Employers' Difficulties in Introducing Women Labour.—But besides overcoming the objections of trades unionists, his own prejudices, and the difficulties of training unskilled labour, many special arrangements had to be made for the introduction of women into engineering works. Cloak-room and lavatory accommodation had to be provided in conformity with the requirements of the Ministry of Munitions; attention had to be given to bad floors, and heating and ventilating arrangements had generally to be more favourable than in the case of men. Closer attention had also to be paid to the fencing of machinery, and special lifting and conveying appliances had sometimes to be provided. Then generally speaking shorter hours are necessary for women, and there are wages and piece-rate difficulties due to the greater subdivision of work, all of which involve expenditure of time and money in shop reorganisation. When it is remembered that the majority of employers were faced with all these difficulties at a time when they were incredulous as to the capacity of women to produce a satisfactory output, it is easy to realise the task that confronted the Ministry of Munitions in the early stages of dilution.

On the other hand, unsatisfied demands for male labour compelled employers to give serious consideration to the employment of women on almost every branch of engineering work from the heaviest labouring operations to tool-room work and setting-up, and many firms soon realised that good welfare conditions were, in the end, a profitable investment. Only those who, like the writer, have dealt with hundreds of firms on this matter, can realise what an important part deep-rooted patriotism, on the part of both employers and workers, played in effecting the introduction of female labour in engineering munition industries. The author has in mind cases of firms who did not hesitate a moment in entering wholeheartedly on dilution schemes in order to help to meet the national demand as expressed by the Ministry, and there were equally numerous cases of trade unionists who ran the gauntlet of local prejudice and ostracism to devote themselves whole-heartedly to the intensive training of women to fill the gaps in the labour requirements.

General Considerations Regarding the Employment of Women.—There is no doubt that war experience with women in engineering works has entirely destroyed all preconceived ideas as to what constituted "skilled work." Previous to the outbreak of war fully skilled men were regularly employed on work which can now be performed by women after a few weeks' training. It is not that the woman is a skilled worker, but has been put to do a job which is a subdivision of skilled work on which a fully-skilled man was previously employed.

The assumption that is so often made that women become fully-skilled workers in a few weeks is quite a false one. We can speed up the training of engineers by better teaching and apprenticing, but in the author's opinion, neither a man nor a woman can become a fully-skilled fitter or turner under a period of, say, four years. On the other hand, war conditions have enabled women to acquire a measure of skill in a far quicker time than men have ever previously acquired it. This is partly due to the patriotic desire of the women to assist in the war, and principally to intensive shop teaching under manufacturing conditions as opposed to go-as-you-please academic training and drifting through works under pre-war apprenticeship conditions.

Women have generally been found to be accurate and conscientious workers. They acquire a high degree of accuracy quicker than men through possessing a finer sense of touch. It has also been demonstrated that women are highly responsible workers, i.e., that they can carry out with confidence finishing processes on large and costly work, and can manipulate high-speed and heavy machinery, in the operation of which there is a certain measure of risk, such as driving large cranes. Women are specially suitable for such skilled and semi-skilled occupations as tracing, draughting, marking-off the lighter work of all kinds and acetylene welding, while they are capable of acquiring a high degree of skill on subdivisions of accurate tool-room work in turning, milling, grinding and fitting operations.

Generally speaking, women may be said to have excelled in machine work rather than in fitting work. It is a peculiar fact that while women do not easily tire of machining operations with consistent repetition, they do stale on repetition fitting work, and quite a large proportion of them do not find the work sufficiently interesting to induce them to complete their initial training.

With regard to the employment of women on heavy engineering work there is a great deal of misapprehension. It is not generally understood that women can safely handle, in the course of machining and fitting operations, pieces weighing up to 60 lb., and can also manipulate, almost as well as men, with the the aid of lifting appliances any weights over 80 lb. It is on work weighing between 60 lb. and 80 lb. where it becomes questionable whether women can be properly and economically employed. There is the cost of special lifting tackle and handling devices necessary for women that may be obviated in the case of men, and in instances where tackle has been provided for dealing with these weights it has been found that women prefer not to go to the trouble of using such tackle and so overtax their strength by endeavouring to lift weights, which after a time generally results in injury to health.

In regard to output women workers have enormously increased the records of output of all products of a repetition character which were current in munition firms previous to the war, but on non-repetition work it is doubtful whether they have, generally speaking, equalled the output of men.

As an example of increase of output obtained by women as compared with skilled men on repetition work even of a heavy nature the author may cite the case of a factory making 9·2-in. shell. The practice in this factory was to bore the shell in three operations, and the total time taken for the complete boring by skilled men was 3·16 machine hours. Women were substituted for men on the boring lathes, and after one week's practice were able to do the work in an average time of 3·6 hours. In less than three months they had reduced the average time to 1·25 hours, thus increasing the output to two and one-half times its previous figure. Scores of similar instances might be quoted, but it is unnecessary, as facts like the above will have come under the notice of most of the members of this Institution.

It is an important point in the employment of women operatives in engineering work that they should be managed as far as practicable by women. If possible women tool-setters and setters-up should be employed, also women charge hands, sectional forewomen, and, wherever possible, women supervisors and shop managers.

Inequalities of Dilution.—The author has already referred to the readiness shown by some firms to carry out dilution and the unwillingness of others. As dilution has progressed since June, 1915, the disparity of effort has become more and more pronounced throughout the country. Cases are known where two firms, manufacturing exactly similar shells in the same town, employ, in one case 80 per cent. of women, and in the other no women at all. It is easy to realise the probability that such inequality has had a very disturbing effect on both workers and employers. That one firm should have agreed to the employment of female labour, and thereby involved itself in a large initial expenditure of time and money, while another, with a less appreciation of the country's needs, remained indifferent and immune from labour difficulties doubtless did not tend to smooth the path of dilution. On the other hand, it was extremely difficult to bring about equality of dilution and equality of treatment under war conditions; for during the first year of dilution the employment of women on engineering work previously done by men was in the experimental stage, and no hard-and-fast rules could be laid down, owing to the uncertainty of output, the variety of the products, and the unequal conditions and equipment of the works.

Ministerial Action.—The first effort of the Ministry of Munitions took the form of letters of instruction urging firms to employ the maximum number of women and unskilled ineligible men, and it was only natural that some firms should find it possible to comply with these instructions in a greater degree than others. Moreover, it was found that despite the agreements made between the Ministry, the Employers' Federations, and the trade unions, some local shops refused to train and employ women, some groups of workers threatened to strike if their employment were insisted on, and in others strikes actually took place. Then the Ministry appointed a number of dilution officers to visit firms to explain to them what was practical in dilution, what assistance could be rendered by the Ministry's training schools, and generally to urge on firms the necessity of taking steps to increase the employment of unskilled labour. It was inevitable that this course of action (in my opinion the only practical course at the time) should lead to varying degrees of dilution in various shops and districts. The Ministry had at the outset to overcome prejudices on the part of both employers and workmen, arising not only from economic but political considerations, and the task that confronted them at times must have seemed almost insurmountable. The fact that the military and naval forces have been continuously supplied, and that some 950,000 women are engaged today on munitions products, turning out nearly one-third of the total output, gives some estimate of the success which has attended the Ministry's effort.

Two Kinds of Dilution Standards.—What seems to the author the proper method of effecting dilution (now that the experience of the Ministry of Munitions has provided us with the necessary data) is to set up standards indicating the proportions of women, unskilled, semi-skilled, and skilled male labour, that should be employed on specified products, or where there are mixed products, on the work of the factory, segregated into classes of work. For some products such a standard has been set up by the Ministry; for instance, for all sizes of shell from 2·75 in. to 4·5 in., both inclusive, and this has been enforced by the insertion of the following clause in all contracts for the manufacture of these shells:—

"It is a condition of this contract that not later than March 31, 1917, at least 80 per cent. of the operatives employed in the execution of this contract shall be women. The expression 'operatives' shall include those employed in unloading and loading, handling, machining, painting and varnishing, assembling, production and setting of tools, charge hands, viewers, and staff employed on repair and maintenance of machinery, and on inspection."

In all contracts for shell of sizes over 4·5 in. the following clause was added:—

"It shall be a condition of this contract that any directions of the Ministry of Munitions as to the number of skilled or semi-skilled male operatives shall be complied with."

The standards accepted by the National Shell Factory Committee for shell over 4·5 in. are as follow:—

15 in., 12 in., 9·2 in. and 8 in., minimum 70 per cent. women. 6 in. and 60-pdrs., minimum 80 per cent. of women.

It will be observed that while a definite standard is enforced by contract in the case of shell up to 4·5 in., the standard for shells above that size was left to the discretion of the Department, the percentages agreed to being those at which the Department aimed in making its recommendations for dilution.

The effect of the dilution clause in contracts for shells up to 4·5 in. diameter inclusive has been very satisfactory, and some uniformity in labour conditions has now been effected throughout the country. Dilution at the discretion of the Ministry on shells above 4·5 in. diameter has not worked out so well, as there are still wide inequalities in the proportion of women to men employed. For example, in one shell factory turning out 9·2 in. shells no women are employed, while in another making the same shells the proportion of women is 90 per cent. Such a wide disparity is, perhaps, not common, but it serves to illustrate the inequalities that have arisen even in the production of such a simple product as a shell when minimum dilution ratios have not been enforced.

On all "straight-line" repetition products such as shells, fuses, grenades, small arms, motor cycles, small tools, &c., it has been comparatively easy to establish definite ratios of skilled to unskilled male and female labour, but in dealing with such products as guns, standard motor lorries and the like, turned out in fewer numbers, and with shops having a mixed output, it has been found preferable to segregate the total labour into classes in order to arrive at the proportion of women to be employed.

The following Ministry of Munitions dilution standard on gun work is an example:—

Breech Mechanism.	Up to and including 8 in. Percentage of Women.	Above 8 in. Percentage of Women.
Turning, boring, screwing, milling, gear-cutting, planing, shaping, slotting, grinding and all other machining operations	80	70
Gauging and viewing ...	80	80
Marking-off, fitting and assembling	50	40
Average for whole department, including proportion of tool-room, smiths' shop, beltman, millwrights, general labour, &c. ...	60	50

NOTE.—In calculating the above percentages all foremen, charge hands, supervisors and tool-setters are to be taken into account.

The percentages were fixed before much information was available. In some works higher percentages have been employed.

Making and Repairing Guns.—In connection with the work of making and repairing guns up to 8-in. howitzers, it was considered that for the following operations the number of male should not collectively exceed the number of female operators:—

Rough turning.
Finish turning.
Rough boring.
Second boring.
Finish boring.
Rifling.
Planing.
Wire winding.

This standard was set up in such a way as to permit a considerable amount of flexibility in its adoption in different works. For instance, it enabled a firm preferring, owing to peculiarities of their machinery or other causes, to employ more than 50 per cent. of women on one of the operations and less upon another to keep within the standard in the aggregate.

Requirements of an Ideal Dilution System.—In considering the question of dilution in its general aspect, it is not difficult at this period of the war, and with the accumulated experience of the Ministry of Munitions available, to lay down the main principles which should have governed action. The problem broadly may be stated thus: The nation has decided upon a certain programme of munitions production as representing its minimum needs. To carry out this programme the number of skilled and semi-skilled men available was inadequate, and at any rate as far as the skilled men were concerned incapable of much expansion. There was, however, a considerable number of men, and a much larger number of women, whose energies could be diverted from their normal occupations to the production of munitions. Now the munitions programme to be carried out involved in its last analysis the provision of a certain number of labour-hours, and it was the object of dilution to provide these. The man-hours of skilled labour available had to be distributed as fairly as possible over the whole programme, and supplemented in an equally fair and general manner by unskilled labour which could be drawn from other occupations. It was, moreover, a primary necessity, and one that could never be lost sight of, that the limited supply of labour which was available should be utilised in the most efficient manner, and that waste of labour, by reason of inefficient machinery or bad management, should be stopped. The country could not afford such waste. Firms guilty of it should logically have been suppressed, and their equipment and labour transferred elsewhere, where it

would be more productive. On the other hand all firms producing their allotted output with a minimum of labour should have received encouragement to extend, a steady supply of orders, priority in their demands for material and labour, and assistance generally in the economical output of munitions.

Lower Efficiency Standard.—Now in order to detect inefficiency of manufacture and to conserve labour for productive purposes, it was essential that some standard of efficiency should be set up—in other words a definite number of labour-hours should have been allotted for the completion of a given contract, and steps have been taken to see that this allowance of labour was not exceeded; in other words manufacturers should have been rationed for labour in proportion to their output. This might have borne hardly upon firms with antiquated machinery and situated unfavourably for economical production, but in a national crisis consideration for such firms would be misplaced sentiment. For their waste is of the nation's wealth.

Dilution Standard.—In addition to the labour efficiency standard above described, a second standard should have been set up for all munition productions, viz., the percentage of female or unskilled labour to the total labour which should be employed on a given contract. This second standard, which may be called the dilution standard, would, by its enforcement, have brought about an equality of treatment between different firms, and spread the difficulties of training and employing unskilled labour fairly among contractors.

Dilution and Industrial Efficiency.—Under our ideal dilution scheme, therefore, firms would have been required so to organise and equip themselves as to require only the standard number of labour-hours to complete a contract for any given product; and, secondly, they would have been required to attain this result without a greater proportion of skilled labour than that permitted by the dilution standard. It cannot be gainsaid that the determination of a standard of labour efficiency lies at the very root of economical production, and it would set for the first time in manufacturing, at any rate so far as Government orders are concerned, an attainable ideal of economical production and establish a criterion by which the respective merits of various firms could be judged. And, further than this, its adoption would involve implicitly a fairly close pre-determination of a contract price for a given product, which would allow a reasonable margin of profit to well-managed firms, and a fair rate of wages to the workers. The Government would have been able to make much better bargains than at present, and it is probable that the efficiency of manufacture and organisation practically imposed upon contractors by the standards expected of them, would have left them, on the whole, more favourably placed than they now are. The standard is the antithesis of the system of "time and line" contracts so much favoured at present by certain Government departments, and would have abolished that system entirely except in very special cases, because the only justification for such contracts is lack of the data needed to estimate fair prices. The effect of the system of "time and line" is to sap the foundations of efficiency—as the more money a contractor can spend or waste on a given job, the greater is his profit.

Determination and Application of Standards.—It now remains to be considered how such standards can be practically determined. Their enforcement, when determined, is not difficult under present conditions, because firms could be graded by an index number, jointly proportional to their percentage attainments of the two standards, and such index number would determine their position on all priority lists, whether for the placing of fresh contracts or the supplying of additional labour, material or equipment. Firms that either could not or would not so organise themselves as to meet the national requirements of the efficient utilisation of labour would automatically find themselves gravitating towards the bottom of the list with the prospect of ultimate suspension owing to necessary labour and materials being diverted to their more efficient competitors. The question of the labour efficiency standards is merely the same problem, only on a larger scale, that confronts every works manager when framing an estimate or setting a piece-work price. He must make an approximate estimate of the man-hours necessary for the execution of a contract before putting in a tender. The author hopes that in future contracts for munitions of war the Government will follow a similar course, collate the information available, frame standards, and enforce their application. It follows that such official estimates must be most carefully prepared and continually revised with the progress of the art of manufacturing. Where munition products or any other articles made in large quantities by various firms are concerned, the standard number of labour-hours required for a given output may be obtained from the actual records of the best firm—thus a practicable standard is set up which can be reached by anyone who will employ equally efficient methods of production. In the same way the largest measure of dilution attained in any industry might be accepted as a standard. The standards so fixed would not be open to serious criticism on the grounds of impracticability of attainment. They would, however, be only provisional, as it is clear that they would be considerably below those which might be set if the practices of a considerable number of firms were analysed, and the standards based on a composite selection, in the same way that the best bouquet would be made by bringing together the finest blossoms from a number of plants. It is by no means uncommon to find two firms taking approximately the same number of man-hours to make a given product, and yet to find so great a difference in the man-hours required for certain of the processes involved that if each firm would adopt the practice of the other whenever it was more efficient, the result would be materially to improve the efficiency of both firms. Similarly if women can be successfully trained to perform an operation in one firm, the employment of women might reasonably be enforced on the same operation in other firms, and thus an economy of skilled labour might be obtained which would be considerably greater than that reached by any particular firm.

Difficulties Due to Variety of Products.—The attainment of a high manufacturing efficiency is very difficult when the energies and interests of a firm are spread over the production of different kinds of products, unless the output of each product is sufficient to justify a separate department, machinery and staff for its manufacture. It cannot be turned out as quickly, cheaply, or with so great a percentage of female labour as it would be under conditions of proper repetition manufacturing, and in the national interest, therefore, firms should be confined as far as possible to the manufacture of the minimum number of different articles. This applies particularly to the case of gauges, cutters, small tools, &c., which in the aggregate absorb a vast and needless amount of highly-skilled labour when manufactured in small quantities by firms for their own use. In the interests of the conservation of skilled labour it would be well if all standard tools and gauges required for munition work were manufactured as repetition products in factories set apart for the purpose. In a word, the production of gauges and small tools of all description should be placed on the same basis as that of shells, fuses, or other direct munitions of war. A beginning in this direction has been made by the Ministry of Munitions who now have some gauge and tool factories in operation.

Standardisation of Methods of Manufacture.—The author has already explained how labour efficiency and dilution standards could be arrived at by merely adopting the actual figures of the attainments in each respect of the best firms. But in order to determine the highest practicable standard for any given product more information is required. It is necessary to analyse methods of manufacture down to the smallest details, and to consider every operation in turn both from the point of view of the labour hours involved and of the class of labour necessary to perform it. Such an analysis is no doubt made now in greater or less detail by every firm when planning methods of manufacture, but the author holds strongly that for all munition products the Government should supply such information to contractors. It would avoid all controversy about the possibility of attaining either the efficiency standard or the dilution standard required by the Government, because the possibility could be proved by actual performance. The author does not, of course, advocate compulsory adoption of the standardised methods of manufacture where firms can produce equally good results by any other methods. But the standard established would assist them in planning work and complying with the Government's requirements as to the maxima of time and labour permissible for a given output. The first objection which will arise in the minds of critics is that all firms are not equally well equipped for production, and that it would therefore be unfair to insist upon the standards of time and labour being universally adhered to. In answer to this the author would say that his proposal would have the effect of preventing firms obtaining contracts which they are unable to carry out efficiently, and this would obviate the waste of material and labour which now exists. Furthermore, it would justify the application of a firm for such machine tools as would enable it to carry out its contracts in the most efficient manner, and would, therefore, rapidly bring about the proper equipment of manufacturing firms for their special products. It would also have a good effect in the standardising of the best machine tools with a corresponding increase in the number available of the best types.

In conclusion, the author would like to make a suggestion that this Institution should set up a committee to study and report on the best methods, in each engineering industry, of introducing women into works, the best way of training discharged soldiers, with special reference to methods and appliances for employing maimed men, the upgrading of workers, the best methods of training male and female labour and cognate matters. Such a committee could collect the experience of the members and make it available for the benefit of the whole, besides placing such invaluable records at the disposal of Government departments dealing with labour dilution, reinforcement and supply. This would not only be a valuable war work, but would have a lasting effect on British industry after the war, by helping to establish standards of output, standard methods of subdividing work and the adoption of such plans as would give the best results in the various branches of engineering industry. Thus such a committee could help the country to preserve for the benefit of British industry the dearly purchased experience gained in the struggle through which we are passing.

APPENDIX.

THE EMPLOYMENT OF WOMEN.

The following is a brief summary of work which was carried out wholly or partially by males before the war, and is divided under four headings: (1) Construction; (2) War Work; (3) Operating, and (4) Miscellaneous Processes.

1.—CONSTRUCTION.

Aeroplanes.—The employment of women on covering, doping, painting and varnishing planes, ailerons, tail-planes, rudders, &c., has been general, and in many cases the work is done entirely by women.

The woodwork of aeroplane wings, ailerons, tail-planes and many subsidiary details has been done throughout with the exception of machining, by women in many cases.

The work of assembling wings, ailerons, tail-planes and details, is done in many cases by women, but the erection of fuselages as sides, and the complete assembly of fuselages by women is rare, as also is the assembling of wings and the fitting of controls. The employment of women in higher grade work of this kind has been influenced by local conditions of management and by method, particularly where assembling is performed by a large number of highly-specialised gangs, as is the case in a few of the larger works.

Airships, Balloons, &c.—The employment of women is partial, but comprises a very large percentage of the total workers, and their employment is frequent in this industry.

Ball-Bearings.—A large proportion of this work was done by women before the war, but the percentage has increased considerably throughout this industry.

In all the preceding cases the work is of such light character and so free from special conditions that no changes have been necessary except the usual improvement in guards where machinery is used.

The period of training required varies from two to six weeks before the women workers can be considered efficient under preliminary conditions, with adequate supervision, and some assistance from skilled workers.

Boiler-Making and Boiler Fittings.—This comprises the construction of boiler drums, from bending the plates to drilling and clamping in place; drilling tube plates, bolting temporarily together, riveting, caulking and making fittings. In all these branches the introduction of women has been partial, but not frequent, except in the case of boiler fittings, which is the only class of this work considered suitable for women in normal times. The employment of women on semi-skilled and unskilled work has required training varying from a few days to four weeks.

Constructional Engineering.—This comprises the running of shearing, punching, bending and other machines, also temporarily bolting together and riveting up the bracing of girders, &c., by machine or portable hydraulic riveter. The same remarks apply as in the case of boiler-making. In some cases the work of painting is done partially by women, but this is not yet general.

Electrical Engineering.—Whereas the machining and erecting of large dynamos and motors is now only partially effected by women in rare instances, and is not considered suitable for them in normal times, the machining and erecting of small dynamos and motors is of frequent occurrence. The same applies to the stamping out of laminations for armatures and transformers; forming, winding and taping coils; the making of paper and micanite tubes and moulded insulators; the making and erecting of switch gear of all kinds; the making of electrical instruments, meters, and of arc lamps. In all these the employment of women is frequent and partial, and the work is suitable for them in normal times without change in method of working.

Internal-Combustion Engines.—On the construction of the various parts of the engines for motor cars, motor lorries, and aircraft, as well as on gas and oil-engine parts not too heavy to handle, the employment of women is partial and frequent, but on gas and oil-engine parts too heavy to handle, involving increased labour and special lifting tackle, the employment of women is partial and rare, and the work cannot be considered as suitable for them in normal times.

Locomotive Engineering.—The machining of engine parts has been undertaken partially by women in some shops and obviously much of the smaller work falls under conditions analogous to those of other allied engineering trades.

Machine Tools.—Small and large machine tools have both seen the partial introduction of women labour in very frequent cases. The work on small machine tools is considered suitable for women, whereas that on large machine tools is not, for the reason that increased labour and lifting tackle would be required.

Marine Engineering.—In the construction of ship hulls no application of woman labour has been made, nor is it considered practicable owing to the heavy character of the work and the amount of climbing involved; but on the construction of engines and turbines, for the work of painting, scaling, &c., and for the electrical wiring of ships partial application has been made in not very frequent cases.

Motor Lorries, Cars and Motor Cycles.—The engines and transmission gear as well as other components are frequently made partially by women. The period of training varies from one to six weeks, and requires ability to work to gauge. Work on the chassis of cars and lorries is of rarer occurrence and is not considered suitable for women in normal times, the period of training required is from six to ten weeks, but the work is generally considered rather too heavy. On magnetos, carburettors, and speedometers the work is in some cases now more than half done by women, and is eminently suitable for them, requiring no change of method or machinery but considerable accuracy and care. The training period varies from three to ten weeks.

The body work of motor lorries, motor cars, as well as upholstering and trimming are not considered suitable for women, nor have they been employed on these for the reasons that the carpentering on lorry bodies is considered too heavy, and the coach-making thought to require so much skill that in general it would not pay to employ women on this class of work. The objection to women upholsterers and trainers is peculiar, as they have done this work successfully on railway coaches.

Railway Carriages and Wagons.—The whole of the work on underframes, wheels, axles, truck bodies, railway carriage building, railway carriage upholstering, painting glazing, &c., has not afforded scope for the introduction

of women at present. It is a fact that in pre-war times the trimming and upholstering of railway carriages was done by women in certain cases. The objections now raised are that the work is too heavy in the earlier classes and rather heavy in the latter.

Steam Engineering and Pumps.—The machining and fitting of light parts has been done partially by women in rare cases. For machine and bench work a training of from one week to six months is required.

Precision Work and Tool-Room Work.—This involves the making of engineers' gauges of all kinds, including those for screw threads, all cutting tools such as taps, dies, cutters, twist drills, reamers, and all jig details and parts. The partial adoption of women labour in all these classes is frequent, and the work is considered suitable for women with training in the use of measuring instruments of from three to eight weeks.

The making of measuring and drawing instruments involves rather higher skill, and the application of woman labour to such work is extremely rare at present.

2.—WAR WORK.

Guns and Gun Components.—This comprises jackets, tubes, &c., breech mechanism, gun sights and gun carriages. The employment of woman is partial and rare on all except on the breech mechanism on which it is frequent. Both this and gun sights are considered work of a class suitable for women. The training period required varies from one to six months, and owing to the skill involved, women require increased experience for such work as gun sights.

Small Arms.—Partial work by women is general. It is considered suitable for them, and the training period varies from six to twelve weeks.

Rifles, Lewis Guns and other Machine-Gun Work.—Though highly accurate are well inside the ability of women.

Shells and Components.—The forging of shells and adapters as well as cleaning, painting and stamping of shells over 4 in. diameter is only done in rare instances partially by women, and is not considered suitable work for women in normal times. All of these are unskilled operations requiring little training, but the nature of the work is too arduous and too heavy for women.

The operations on machining shells over 4 in., and of general labouring in shell shops are now generally performed partially by women, but the work is not considered suitable for women in normal times because of the increased amount of lifting tackle required and the heavy handling involved, except where the shops are specially laid out for this product.

The machining of shells up to and including 4 in., of base plates and adapters, of nose bushes, gaines and fuses, the gauging and viewing of shells and components, and the cleaning, painting and stamping of shells up to and including 4 in. is partially performed as a general rule by women, and is considered of a character suitable for women, as these operations involve no change in methods of this semi-skilled work, which requires a training of from one to three weeks only.

3.—OPERATING WORK, NON-CONSTRUCTIONAL.

Crane Driving.—The introduction of women into this branch has been partial but frequent. It is considered suitable work for them, but the cranes, when of the overhead type, require, in many instances, better facilities for access. For such rough and heavy work it is, of course, necessary that the women workers should be suitably clothed; this applies also to work on large aeroplanes, and on aeroplane erection, as well as on boiler-making and constructional engineering.

Power Plant and Electric Station Work.—The work of operating boilers, gas producers, &c., is not performed by women except in very rare cases, and is not considered suitable for women in normal times. General labouring in power stations is at present done in rare instances by women, but it is also not considered suitable, on account of the climbing and risk involved.

Operating steam engines, gas engines, dynamos and electrical switch gear is partially done by women in some instances. The training involves knowledge of the principles and construction of the machinery, and in the case of switch attendants an elementary electrical knowledge. The period of training varies from one or two weeks to six months. One objection to the employment of women on this class of work is the shift system, universal in power stations, which involves a change of shift at midnight, a time which would generally prove unsuitable for women.

4.—MISCELLANEOUS PROCESSES.

Acetylene and Electric Welding.—The partial employment of women is generally on this class of work, and it is considered suitable for them in normal times without change of method. The requisites are care and experience and a training period of from one to ten weeks.

Lacquering, Bronzing, Enamelling, Painting and Stencilling.—The partial employment of women is general, it is considered suitable for women in normal times; care and a short training of from one to three weeks are all that is required.

Blue Printing and Tracing.—The partial employment of women is general, it is considered suitable for normal times, care and neatness are the chief requisites with a training period of from one week upwards.

Draughtsman (Junior).—The employment of women is here more rare, but it is work considered suitable. Knowledge of machine-shop work is necessary, and the training involves that for blue printing and tracing as well as additional experience in drawing and projection. The need for shop experience is great, but the difficulty attendant on the employment of women in this branch is diminishing owing to the increase in the number of works in which women have been employed in working, from actual drawings, and not on mere repetition.

Tool-Setting.—The partial employment of women is frequent, and the work is suitable for normal times. The requisites are either considerable experience as an operator, culminating in setting own tools, or a course of four weeks and upwards of specialised setting on machines of the same class. The tool-setter who can set up for any kind of work is highly skilled, but when the question is reduced to a particular class of machine, or of machine work, the field is limited, and the skill is reduced to more specialised limits.

Viewing and Gauging.—The partial employment of women is frequent, and it is work that is considered suitable for women in normal times, in fact, women have been employed in pre-war time in many branches of industry in viewing operations. The limitations occur when parts are too heavy for them to handle, or when experience of materials, such as timber, is vital. The training involves accuracy and intelligence as well as ability to understand drawings, and instruction in the use of measuring appliances for a period of from one to six weeks. In some instances experience of specialised character is necessary to determine whether the finished workmanship, or material or other variables, are satisfactory.

Wire-Drawing and Winding.—These operations are not performed at present to any great extent by women, though they are considered suitable for them in normal times. The requisites are knowledge of the process, a short training of one or two weeks; the only limitations are those imposed by want of physical strength.

Making and Breaking of Test-Pieces.—The partial employment of women on making and breaking test-pieces is not very common, but it is work considered suitable for women in normal times; the requisites are ability to read drawings and measuring instruments, combined with a knowledge of accurate turning on the centre lathe, or precision grinding, together with a training of three to six weeks in the operation of a testing machine. The breaking of test-pieces is in many cases a fairly simple operation when the yield-point of the metal is well marked, but in the case of some steels and some non-ferrous metals, greater experience in testing is necessary, as much may depend upon the observation of the yield-point of the individual material under test. All the auxiliary work of measuring the test-pieces before and after fracture as well as the calculations involved in the determination of the elastic and ultimate tensile strength, percentage of elongation and reduction of area, are well within the capacity of women who can machine the test pieces, use the slide rule and work the testing machine.

PLANT GROWTH UNDER ARTIFICIAL ILLUMINATION.—Some new experiments made by Dr. C. P. Steinmetz and Mr. J. L. R. Hayden in the former's orchid house about Christmas, 1916, on the hastening of plant development by artificial light are hardly encouraging for ordinary conditions. They suspended (*General Electric Review*, March, 1918, pages 232 to 236) five gas-filled Mazda lamps of 500 watts 36 in. above the ground, 17 in. apart, over a bed, 5 ft. by 9 ft., and kept the five lamps continuously burning day and night for 44 days, after which two lamps were kept on for 29 more days. The power consumption was first 2·5 kw., which averages 55 watts per square foot and corresponds to an illumination of 700 lumens per square foot of ground; the temperature of the hot-house, about 18 deg. or 20 deg. C., was raised by 2 deg. C. by the lamps. The plants selected for the experiment were Henderson's dwarf wax-bush beans. The beans in the small check-plot, a box 36 in. square, received only daylight. The rate of development was nearly doubled by the artificial light and heat, but it cost a great deal to approach direct sunlight effects as was done in this case. It is pointed out however, that some plants, flowers, and fruit temporarily command very high prices during the winter; for such purposes artificial illumination is commercially used already, of course.

IRON AND STEEL WORKS FOR QUEENSLAND.—The Royal Commission which was appointed last year to inquire into and report upon the advisability of establishing State iron and steel works in Queensland (Australia) has furnished a progress report, in which the commissioners say that a great deal of research work will be required to be undertaken and much more information collected before they can make recommendations with regard to the establishment of a complete iron and steel works. A geologist has been deputed by the Queensland Minister for Mines to collect information respecting the quantities and suitability of raw material available. Sufficient evidence, however, has been placed before the commissioners to justify them in coming to the following conclusions: (1) That all the essentials are in Queensland for the successful manufacture of pig-iron; (2) that a complete plant for the manufacture of pig-iron can be established at a cost not exceeding 5,000*l.* (roughly, 25,000 dols.); (3) that such a plant could be utilised for the testing in bulk of iron ore from different parts of the State, thus deciding whether the various deposits are suitable for smelting and converting into steel; (4) that, taking present prices and the rates that must obtain for at least a considerable time after the war, the making of pig-iron would be a profitable undertaking for the State; and (5) that the site chosen for such works would not in any way affect the selection of a site for central iron and steel works, if finally decided upon by the commission. The commission therefore recommends that steps be taken forthwith to establish, at a site to be chosen by the Mines Department, a State iron smelting plant capable of producing pig-iron commercially and of testing in bulk the iron-ore deposits of the State.

SHIPPING AND SHIPBUILDING IN SWEDEN.

THERE are no signs of an abatement in the efforts on the part of Sweden to increase both her shipping and her shipbuilding industry. The Svenska Lloyd Company has decided to double its capital, which at present amounts to 9,700,000 kronor, and although it has a fleet of 42 steamers, of about 90,000 tons deadweight, and 14 additional steamers are in the course of building, representing some 45,000 tons, the placing of further contracts is under consideration. A new steamer company has been formed in Stockholm with a capital not exceeding 9,000,000 kroner, and 9 vessels of an aggregate tonnage of 56,000 tons have already been ordered, the contracts having been placed with the new Oresund yard at Landskrona. A new shipyard is being started at Västeras, and slips are already in course of erection; the yard is intended for small vessels, of from 600 tons to 800 tons, and five slips will be built. Such yards for comparatively small tonnage are being erected in several provincial Scandinavian towns.

There is also some likelihood of the Swedish State going in for shipbuilding, and an expert commission has been considering the question of extending the Karlskrona dockyard so as to enable it to build other vessels for the State than warships. The problem of building vessels other than warships by the State is one of great importance, and one which cannot be deferred indefinitely. A large goods steam ferry for the Trelleborg-Sassnitz route is needed, and also additional steam ferries for the Malmö-Copenhagen and the Helsingborg-Elsinore traffic. A daily State steam ferry connection between Gothenburg and the English East Coast has also been freely discussed and advocated. Further, the plans of establishing a steam ferry connection between Sweden and some Russian Baltic port are also likely to be taken up in earnest after the war. The question of a sea-going icebreaker also awaits solution. Lastly, there is also the matter of State cargo steamers so as to make sure of certain important supplies, should certain contingencies arise.

THE RISE IN THE PRICE OF TONNAGE.—The Swedish, Commercial Department has prepared some statistics about the rise of the price of tonnage during the war, from January, 1914, to March, 1918. Steamers of not less than 500 tons and not more than 25 years old cost during the six months prior to the war, January–June, 1914, 110 kroner per ton net, and in January–March, 1918, 1,885 kroner per ton net. Sailing vessels of not less than 50 tons and not more than 25 years old, rose during the same period from 52 kroner to 599 kroner per ton net. It is more especially the larger boats which have headed the rise, and for such the prices at the commencement of the present year were 17 times as high as at the commencement of the war. The rise has not been according to an unbroken curve, but has been most pronounced during the spring and the summer. The prices for sailing vessels have not increased to the same extent, although recently prices have been paid 11½ times higher than at the beginning of the war.

BRAZING STELLITE TO STEEL SHANKS.—A method of brazing stellite to a steel shank is illustrated in *Machinery* New York. A thin web is left on the side of the shank opposite the cutting edge of the bit; the thickness of this web is governed by the width of the bit and it should be chamfered at about 45 deg. and to a depth of approximately one-fifth the depth of the bit. The leaving of this web insures enough copper in the joint prior to lifting the tool from the fire. The stellite tip and shank are placed in the forge and allowed to soak in the fire until white hot, when a thin sheet of copper should be placed between the steel shank and the stellite tip, borax being freely applied. The tool is then brought to a white heat, or to such a point as will soften the stellite slightly, additional copper being melted from time to time, either from a piece of copper tube or copper sheet and allowed to flow in the chamfer. In this way, the copper will run down and wash away any dirt and at the same time exclude the air, and do away with oxidation. When the tool begins to soften slightly, it should be removed from the fire and squeezed slightly in a vice or with a pair of tongs. Tools made in this manner are capable of standing any stress up to the point of breaking the shank.

ELECTRIC FURNACES.—We read in *The Iron Age*, New York, that with the advent last year of 20-ton electric furnaces and indications of an advance to a standard maximum of 30 tons, the General Electric Company developed a system of automatic control to handle the motive power necessitated. The improvements became necessary as the rate of steel production in these furnaces had been increased by the use of higher capacity transformers and higher voltages, which permitted forcing power into the furnace at considerably higher rates. The higher power used can be seen by taking, for example, the 6-ton furnace, which is the size in greatest general use. The transformer capacity has increased from 900 k.v.a. to 1,500 k.v.a., and even 1,800 k.v.a. has been proposed, all these capacities being based on 100 volts. In the variable voltage equipments, the successful use of 150 volts renders it possible to increase the normal 1,500 k.v.a. up to 2,250 k.v.a. Although 100 volts remains standard for refining, voltages up to 173 have been used for melting, these pressures being obtained either by high-voltage taps or high-voltage Y-delta connections. The use of high voltages during melting down is to permit of decreasing the current for a given input, to improve the power factor and to insure higher emergency input when most needed.